

**Philosophical principles of religion: natural and revealed. In two parts ... /  
by George Cheyne.**

**Contributors**

Cheyne, George, 1671 or 1672-1743.

**Publication/Creation**

London : Printed for George Strahan, 1715-1716.

**Persistent URL**

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Metaphysical Principles  
OF  
RELIGION  
NATURAL  
AND  
REVEALED

---

TWO PARTS.

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LONDON

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MILK-MAN'S HEAD, in the Strand, near the  
Royal Exchange.



*Philosophical Principles*  
 O F  
 RELIGION:  
 N A T U R A L  
 A N D  
 R E V E A L E D:

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In Two PARTS.

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Part I. Containing the *Elements of Natural Philosophy* and the Proofs of NATURAL RELIGION arising from them. The Second Edition Corrected and Enlarged.

Part II. Containing the *Nature and Kinds of INFINITES*; their ARITHMETICK and USES: together with the *Philosophick Principles of REVEAL'D RELIGION*. Now first Publish'd.

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By GEORGE CHEYNE, M. D. and F. R. S.

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L O N D O N:

Printed for GEORGE STRAHAN at the *Golden-Ball* in *Cornhil*, over against the *Royal-Exchange*. M D C C X V.



To His GRACE

JOHN

DUKE of ROXBURGH

Marquess of Bannockburn and Cessford, Earle of  
Kells, Viscount of Brexmonth, Baron King of  
Cessford, and Garvintoun, &c.

Keeper of His MAJESTIES Great Seal, in  
Scotland.

May it please your GRACE,

As you considered to do me  
the Honour to suffer your  
Name to be prefixed to the  
former Edition of this Work:  
So I humbly Hope, Your  
GRACE will continue the same Goodness, to this  
more full and correct One. I so deeply and  
justly Honour Your GRACE, that as I am sure  
you do not expect, so I own I dare not bestow,  
the Compliments usual in Addresses of this  
Kind. That Your GRACE may Live an  
Example



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To His GRACE  
**J O H N,**  
DUKE of ROXBURGH,

Marquess of *Bowmont* and *Cebsford*, Earle of  
*Kelfo*, Viscount of *Broxmouth*, Baron *Ker* of  
*Cebsford*, and *Cavertoun*, &c.

Keeper of His MAJESTIES Great Seal, in  
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the Compliments usual in Addresses of this  
Kind. That Your Grace may Live an  
Exampel

---

Example of Solid Virtue, in your High  
Rank here, and may be Crowned with an  
exceeding Weight of Glory hereafter, is  
the Earnest Prayer, of

---

May it please your Grace,

Your Grace's

most oblig'd

most Faithful,

most humble Servant,

---

By GEORGE CHAVAN, M.D. and F.R.S.

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LONDON:  
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den-Ball in Cornhill, over against the Royal

Exchange. MDCCLXXV.  
GEO. CHEYNE.

PHILOSOPHICAL  
PRINCIPLES  
OF  
Natural Religion.

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PART I.

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Containing the

ELEMENTS

OF

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And the PROOFS for

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Arising from them.

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The Second Edition, Corrected and Enlarged.

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By GEORGE CHEYNE, M. D. and F. R. S.

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THE  
PREFACE

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To the first Part

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Had not given the World  
any further Trouble with  
my poor Labours on such  
uncertain and intricate Sub-  
jects as are here treated  
of, had I not been often sollicit to give  
orders for another Edition of this Work,  
for the Use of the Younger Students of  
Philosophy, who while they were taught  
the most probable account of the Appari-  
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veries, might thereby have the Prin-  
ples of Natural Religion intently intill'd  
into them at the same time. This with  
the Consent and Approbation of those  
whose Advice will be always sacred with  
me, were the Principal Motives to this  
Edition; and while it was under Hands,



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THE  
P R E F A C E

To the first Part.



Had not given the World any further Trouble with my poor Labours on such uncertain and *intricate* Subjects as are here treated of, had I not been often Sollicited to give orders for another *Edition* of this Work, for the Use of the Younger Students of *Philosophy*, who while they were taught the most probable account of the *Appearances of Nature* from the Modern Discoveries, might thereby have the *Principles of Natural Religion* insensibly instill'd into them at the same time. This, with the Consent and Approbation of those, whose Advice will be always sacred with me, were the Principal Motives to this *Edition*; and while it was under Hands,

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THE PARALLEL.

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I was inclined to have it as correct and full, as the Animadversions and Corrections of those *Friends*, who were capable and willing to undertake them; my own low Abilities, uncertain Health, and necessary Avocations wou'd permit. I had seen the Observations and Corrections, by the late Ingenious and Learned Dr. Gregory, Savilian Professor of Astronomy, at Oxford, had made on the former Edition of this part. I had some Remarks from the Reverend and Learned Mr. John Craig, as also some very Judicious Reflections from a Gentleman at Cambridge who conceals his Name. These I freely used, with the best Judgment and utmost Application I was capable of, to make the Corrections and Emendations of this Part now again Published. As to the Additions, besides what my own Reflections suggested, the principal ones were taken from the Second Editions of Sir Isaac Newton's (that great Inventor and Improver of most of our Modern Philosophy and Geometry) his *Opticks* and *Mathematical Principles*

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THE PARALLEL

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principles of Philosophy; Mr. Cotes, (the Learned Plumian Professor of Astronomy at Cambridge) his Preface to that Edition; the Reverend and Learned Mr. Derham's two late Pieces; the Philosophical Transactions, and the Memoirs of the Academy Royal at Paris. I Intended to have had these Alterations and Additions printed by themselves, for the Benefit of those who had the first Edition, but I found it was impracticable.

I am very Sensible, the best accounts of the Appearances of Nature (in any single Instance how minute or simple soever) Humane Penetration can reach, comes infinitely short of its reality, and internal Constitution; for who can search out the Almighty, or his works to Perfection. Some of the grosser Out-lines and prominent Lineaments of Nature, are as near, as is allowed to Mortals to approach. But this I think I may venture to say, that Atheism, may be Eternally confounded, by the most distant Approaches to the true causes of  
Natural

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# The P R E F A C E

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Natural Appearances. And that if the *Modern Philosophy* demonstrates nothing else, yet it infallibly proves *Atheism* to be the most gross Ignorance.

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*Philosophical Principles*  
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PART I.

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CHAP. I.

*Of the Physical LAWS of NATURE.*

§ I.



HERE is nothing a more common Subject of Discourse than *Nature* and its *Laws*; and yet, however Use has made these Words familiar, there are few that agree in their Notions about them: The Reason of which seems to be, that these Terms imply *Notions* so compounded, and so far re-

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mov'd from the Knowledge of most Men, that there are scarce any that distinctly conceive all the Simple *Ideas* that enter their Composition; I shall not pretend to settle the Signification of these Words in their utmost extent (That being perhaps above the power of Human Faculties in this *Lapsed* estate) it will be enough to my present purpose, to give the Sense I shall apply to them in the following Discourse.

§ II. By *Nature*, I understand this vast, if not infinite *Machin* of the *Universe*, the Perfect and Wise Production of Almighty God, consisting of an infinite Number of lesser *Machins*, every one of which is adjusted by Weight and Measure. By the *Laws* of *Nature*, I mean, those Laws of Motion, by which natural Bodies are commonly govern'd in all their Actions upon one another, and which they inviolably observe in all the Changes that happen in the natural State of things. But here we are to distinguish between the Laws of *Creation* and those of *Nature*, for not only the great Bodies of this *Universe*, but the inferiour *Machins* thereof, were formed by a different Law from what they are now govern'd. For none of the *Laws* of *Motion* or *Nature* now establish'd, will any way serve to account for the *Production*, *Figure*, *Size*, *Motion* or *Number* of the *Great Bodies* of the *Universe*. nor of their *Appendages*, tho' they may help us a little to conceive their *Appearances*, now they are Created, and put in regular and beautiful

Motions:

Motions. But this will be more distinctly explain'd afterwards.

§ III. That there is no such thing as an *Universal Created Soul* animating this vast System according to *Plato*, nor any *Substantial Forms* according to *Aristotle*, nor any *Omniscient Radical Heat* according to *Hippocrates*, nor any *Plastick Virtue* according to *Scaliger*, nor any *Hylarchic Principle* according to *Henry Moor*, is evident from the following Considerations; 1. These (as they are now generally understood, tho' perhaps a just and true Sense might be put upon them) are meer *Allegorical Terms* coin'd on purpose to conceal their Author's Ignorance. When some *Philosophers* cou'd not account for the appearances of Nature, they were so far from owning any want of Knowledge, that to keep up their Credit with the thoughtless and credulous part of Mankind, they attributed these unaccountable Effects, to unintelligible Beings of their own Contrivance, which neither had Foundation nor Existence in Nature: But whoever will give themselves the least trouble to consider the Matter, will plainly see, that they really meant nothing by those amazing Terms, but to disguise their own Ignorance. 2. These deputed Beings (as they are commonly understood) are derogatory from the Wisdom and Power of the *Author of Nature*, who doubtless can govern

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## 4 Philosophical Principles

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this *Machin* he cou'd create, by more direct and easie Methods, than employing these subservient *Divinities*. 3. The Appearances themselves, to salve which they were contriv'd, may be by more intelligible and less indirect Principles accounted for, as in some measure shall be afterwards shown. And Beings are not to be multiply'd without a plain Necessity. 4. Lastly, These very *Beings* will not serve the design of their Creation, unless we endow 'em with Powers and Faculties above the Dignity allow'd by their *Authors*, to such secondary Agents. I do not here intend, to insinuate any thing against the Ministry of *Angels*, or the Administration of *Subordinate Spirits* in the *All-Wise's* Government of the World, and in the Works of his Providence: on the contrary, I think that more certain, than any thing in our Philosophy, discoverable by the meer use of Human Faculties can be, since even most of those *Appearances* which we account for from our Philosophick Principles, may, for ought we are absolutely certain to the contrary, be owing to them. But as we are not to have recourse to *their* Agency, without plain Necessity, so *they* were never intended by the Inventers of these *Secondary Agents* I have been now disproving: on the contrary, by these, as they are commonly understood, are meant some Lifeless, Independent, Fanciful Powers, Principles, or Faculties unintelligible in true *Philosophy*, and inconsistent

sistent with reveal'd Religion, though perhaps an Explanation may be made of them *congruous* to both.

§ IV. The *Scheme* of *Nature* which seems most agreeable to the Wisdom of its Author, according to the modern Discoveries, is (supposing the *System of the Universe* already created) that he has settled Laws, and laid down Rules, conformable to which natural Bodies are govern'd in their Actions upon one another, and according to which, the Changes in the material part of this *System* are brought about, which all Bodies inviolably observe, and which of themselves naturally acting, they never transgress in the least degree, whilst *God Almighty* by his *intimate* Presence, in, and with every single part of the Universe, preserves them in their Faculties and Operations. All the *Integral* Parts of *Nature*, have a beautiful *Resemblance*, *Similitude*, and *Analogy* to one another, and to their Almighty *Original*, whose Images, more or less expressive according to their several Orders and Gradations, in the *Scale* of Beings, they are; and they who are Masters in the noble Art of just *Analogy*, may from a tolerable Knowledge in any one of the *Integral* Parts of *Nature*, extend their Contemplations more securely to the whole or any other *Integral* Part less known. Thus this great *Machine* of the Universe has a Resemblance to the lesser One of a *humane Creature*; for, as in the last, the vital Functions are perform'd

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## 6 Philosophical Principles

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form'd by general and constant Laws ; the *Food* is concocted, the *Heart* beats, the *Blood* circulates, the *Lungs* play, the *Secretions* are made by the Laws of Motion, and the constant Rules of *Action* of the lesser Bodies upon one another ; So the great Bodies in the several *Systems* of the Universe, move in their *Orbits*, turn about their *Axes*, and act upon one another according to the establish'd Laws of Motion, and the great Principles of Activity, of these greater Bodies upon one another. Again, as the *spiritual* Part of the humane Compound, is intimately present with, presides over, actuates and enlivens the whole and each Part of the Body, so the *Infinite* Creator and Governour of the *Universe*, is co-extended with infinite Space, is intimately present with every single Point of its Dimensions, presides over the Whole and all its Parts, maintains their Being and their first imprest *Energy*. The *Analogy* might be carried to many, and much more sublime Speculations, but these are sufficient for my present Purpose, which is to shew in the following Sheets, according to my poor Abilities, that the best and most satisfactory Explanations of the *Appearances* of Nature hitherto discovered, do all evince the necessary *Being* and special *Providence* of God *Blessed for ever*.

§ V. It is not my Design here to explain all the particular *Laws of Motion*, and of the Actions of Bodies upon one another, nor cou'd it

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be well done in so narrow a Compass as I have proposed to my self; I shall here only set down the General *Laws of Nature*, which virtually include these others, and infer such Conclusions from 'em as I find most necessary for clearing some parts of the following Discourses.

L A W I.

**A**LL Bodies persevere in the same State of Rest, or of moving forward in a strait Line, unless forc'd out of that State by some outward impress Violence, *that is*, all Bodies at rest will naturally, and of themselves for ever continue in Rest, unless some external Cause put 'em in Motion: And all Bodies in motion will naturally move forwards for ever in the same strait Line, unless they are stop'd by some opposite Force, or turn'd out of their Course by some differently directed Violence.

§ VI. To shew how inviolably this Law is observ'd by natural Agents, we need only consider it never has been observ'd that any Body did of it self bring it self from Rest to Motion, nor that ever any Body in Motion brought it self to Rest; Nor that ever any Body in Motion, of it self altered its Course, but that wherever such Changes happened, there were always evident Causes. If Bodies chang'd their places of themselves, all Things wou'd run in-

to Confusion, nor wou'd there be any certain Means to regulate the *Motions* of the Universe. We are certain *Projectils* wou'd for ever move on in the same right Line, did not the Air, their own Gravity, or the Ruggedness of the Plane, on which they move, stop their Motion; or did not some Body with a different Direction alter their Course. A Top whose parts, by their Cohesion, hinder one anothers rectilinear Motions, wou'd never cease to turn round did not the Air gradually impair its Motion. Natural Bodies consist of a Mass of Matter, which by it self can never alter its State, and if Bodies are once at rest, they must continue so, unless some new Force put 'em in Motion. If in Motion, the same *Energy* will continue 'em in Motion and drive 'em forwards in the same Directions.

§ VII. Moreover, there is in Matter a passive *Principle*, which Sir *Isaac Newton* very well expresses by the *vis inertiae*, whereby Bodies resist to the utmost of their Power, any change or alteration of their State, whatever it be, either of Rest, Motion, or its Direction; And this Resistance is always equal in the same Body, and in different Bodies is proportional to the quantity of Matter they contain. There is required as much Force to stop a Body in Motion, as is required to put it in Motion, and *è contra*; And therefore since the same Body equally resists the contrary equal Changes of its State,

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*five* Principle or *vis inertiae* is essential to Matter, because it neither can be depriv'd of it, nor intended or remitted in the same Body, but is always proportional to the quantity of Matter Bodies contain.

*Corollary 1.*

§ VIII. Hence it is evident that no Particle of Matter, nor any Combination of Particles, *that is*, no Body, can either move of themselves, or of themselves alter the Direction of their Motion; Matter is not endow'd with Self-motion, nor with a Power to alter the Course in which it is put, it is meerly passive and must for ever of it self continue in that State and that Course that it is settled in; and if it can't move of it self, it can never alter its Course of it self when in Motion, for to alter its Course of it self, is only to move of it self after a particular manner.

*Corollary 2.*

§ IX. Hence it is Evident, that no Body put in Motion will naturally, and of it self move in a *Curve Line*. All Motion is naturally forward in the same strait Line with the Direction of the moving Force; but what ever moves in a Curve Line must in every Point alter its Direction, and therefore naturally of it self, no body can move in a *Curve Line*. Co-

## Corollary 3.

§ X. Hence the great Bodies of this Universe the *Planets*, their *Satellites*, and the *Comets* do not naturally and of themselves (tho' at first put in Motion) move in their respective *Orbits*, which are *Curve-Lines* returning into themselves, but are kept in them by some attractive Force, which if once suspended, they wou'd for ever run out in right Lines, and consequently the Motions of these Great Bodies in their *Orbits* do absolutely depend upon this attractive Force, whencesoever it arises.

## Corollary 4.

§ XI. Hence neither Motion nor Rest (I mean not one of 'em particularly) is essential to Matter, *i. e.* Matter is indifferent as to either of these particularly, and does as much resist its being chang'd from Rest to Motion, as it does the being chang'd from Motion to Rest. And as any Force will imprint some degree of Motion on a *quiescent* Body, so the same degree of Force impress'd at the same time with a contrary Direction, will bring it to Rest again, but it is not necessary to the *Being* of Matter that it be in Rest or Motion, for Matter will be still Matter in which ever of these States it be. In a Word, since the formerly mentioned  
passive

passive Principle or *vis inertia* is essential to Matter, it thereby becomes indifferent as to Motion or Rest, and is equally susceptible of either according as the extrinsic Force urges it.

Corollary 5.

§ XII. Hence the Necessity of a *Vacuum*, or space distinct from Matter, is clearly demonstrable; for since by their *vis inertia*, all Bodies resist to the utmost of their Power, any Change or Alteration of their State, whether of Motion or Rest; and since the Resistance in the same Body is always equal, or the same, and in different Bodies is proportionable to the Quantity of Matter they contain; and since consequently, if two Bodies containing equal Quantities of Matter, and moving with equal Celerities in contrary Directions, so that they impinge directly upon one another, will certainly both rest or stop at the Point of their Concourse, as also since it is demonstrable, that two Bodies moving contrary wise with equal Celerities, and both resting at their meeting, are equally Heavy; it necessarily follows, that two Bodies containing equal Quantities of Matter, are equally Heavy, and therefore were there no Vacuities in Bodies, two Spheres of equal Diameters, should contain equal Quantities of Matter, and consequently be equally Heavy, *i. e.* two Spheres of equal *Diameters*,

one of Gold, another of Wood, shou'd have the same specifick Gravities, which being contrary to Experience, there is a Necessity of admitting Vacuities in the latter Sphere to answer the Difference of their Gravities.

It is true, it may be here answered, that one of the equal Bodies may be suppos'd to be more *porose* than the other, and the Pores to be pervaded by a subtle Fluid, which passing freely through the Bodies, is not concern'd in the *Impulse*. And to obviate this Objection, and consequently to make this proof of the Necessity of a *Vacuum* amount to a Demonstration, Sir *Isaac Newton* has shewn from many repeated Experiments by *Pendulums*, in Air, Water, and Mercury; and more exactly by Experiments on heavy Bodies falling in Air, and Water; that the *Resistance* of Fluid Bodies is always proportional to their *Densities*, that is to the Quantities of Matter they contain, or their *Vires Inertiae*. The *Resistance* in Fluids arises from their greater *Pressing* on the Fore, than Hind part of the Bodies moving in them; and this must be always in all Fluids proportional to the Quantity of Matter they contain, which presses on these sides, that is, their *Density*. Bodies moving in Fluids press upon and excite a Motion in the Fluids in their passage; and this Motion thus impressed arises from the excess of the *Pressure* of the Fluid upon the fore-part, above that *Pressure* on the hind-part of the moving Bodies; and this

this excess of *Pressure* of Bodies in Fluids, will not only raise a Motion in them, but will also act on the Bodies themselves, by retarding their Motion, according as it is greater or less, whence the *Resistances* of Fluids arise; wherefore the *Resistances* of Fluids, are as the Quantities of Matter they contain, or their *Densities*, which alone can make the Excess greater or lesser. It is true, there is a Resistance in Fluids which may arise from their *Elasticity*, *Glutinousness*, and the Friction of their Parts, &c. This *Resistance* may be lessend and in a great measure remov'd by the change of the Figure and Size of their Parts. But these Considerations have no place in any of the Fluids of our System, wherein Experiments have been made, it having been always found that their *Resistances* were proportional to their *Densities*. So that no *Subtilization*, *Division* of parts, or *Refining* can alter their *Resistances*, these depending intirely on their *Densities* or *Vires inertia*, that is, the Quantities of matter they contain; and the most Subtile *Æther* would give the same *Resistance* to a Projectile, as *Mercury*, if the Density or Quantity of matter were the same in the first as the last: for that being supposed, the Excess of the Pressure or Weight on the fore-part, above that on the hind-part of the *Projectile* would be the same in both, on which alone the *Resistances* of both depend. Since it is weight alone, that is matter, that can produce *Pressure* in inanimate Bodies.

*Vide*

*Vide Newton. Schol. Prop. XL. lib. 11. 2d. Edit.*  
 From all which it is plain that if Bodies be ever so *Porose* and fill'd with Fluids ever so *Subtile*, yet if there be no *Vacuities* without matter intirely, these *Porose* Bodies must be equally heavy with the most compact ones, since the Fluids requir'd to fill these Pores must be equally heavy with the solid Body, since both must contain an equal Quantity of matter if there be no *Vacuities*, all Fluids resisting, that is indeed weighing, in proportion to the Quantities of matter they contain. If therefore there be no *Vacuities*, all Bodies must be equally heavy, which being contrary to Experience, there is a Necessity of admitting *Vacuities*, to account for the different Weights of Bodies.

## L A W II.

§ XIII. **T**HE Changes made in the Motions of Bodies are always proportional to the impress'd moving Force, and are produc'd in the same Direction with that of the moving Force.

Effects are always proportionable to their *adequate* Causes, and if any Degree of Force produce any Degree of Motion, a double Degree of the same Force will produce a Double Degree of Motion, and a triple a triple, and so on; and this Motion must proceed in the same Direction

rection with that of the moving Force, since from this only the Motion arises; and because by the former Law, Bodies in Motion cannot change their Direction of themselves, so that unless some new Force alter its Course, the Body must proceed in the same Direction with that of the moving Force. And if the Body was before in Motion, the Motion arising from this impress'd Force, if in the same Direction, does so much increase the former Motion; if it has a contrary Direction, it destroys a part of the former Motion, equal to that which is impress'd; when it has a Direction oblique to that of the former Motion, it is either added to, or subtracted from the former Motion, according as the Motion arising from a Composition of these two, is determin'd.

*Corollary.*

§ XIV. Hence it is evident, that in the present Constitution of things, there can be no perpetual Motion. By a perpetual Motion, I mean an uninterrupted Communication of the same degree of Motion from one part of Matter to another in a Circle: not as Bodies put in Motion do for ever continue in the same, but in so far as they are resisted or stop'd by other Bodies, but a Circulation of the same quantity of Motion, so that it perpetually return undiminis'd upon the *first Mover*. For by this  
Law

Law, the Motion produc'd is but proportionable to the generating Force; and all Motions on this Globe being perform'd in a resisting Fluid, *viz.* the Air, a considerable quantity of the Motion must be spent in the Communication, on this *medium*, and consequently it is impossible the same Quantity of Motion should return undiminished upon the *first Mover*, which is necessary toward a perpetual Motion. Moreover, the Nature of Material Organs is such, that there is no avoiding a greater or lesser degree of Friction, though the Machin be formed according to the exactest Principles of *Geometry* and *Mechanicks*, there being no perfect congruity nor exact smoothness in Nature; the manner of the Cohesion of Bodies, the small proportion the solid Matter bears to the vacuities in 'em, and the Nature of the constituent Particles of Bodies, not admitting the same. Besides, how very imperfect our most finished *Mechanick Performances* are, a very ordinary *Microscope* will easily discover. Now these things must very considerably diminish the communicated Force, so that it is impossible there shou'd be a perpetual Motion, unless the communicated Force were so much greater than the Generating Force, as to recompence the diminution made therein by all these Causes, so that the impress'd Motion may return undiminis'd to the *first Mover*. But that being contrary to this Law, it is clear, that the Motion must con-

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tinually

tinually decrease, till it at last stop, and consequently there can be no perpetual Motion in the present State of Things.

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L A W II.

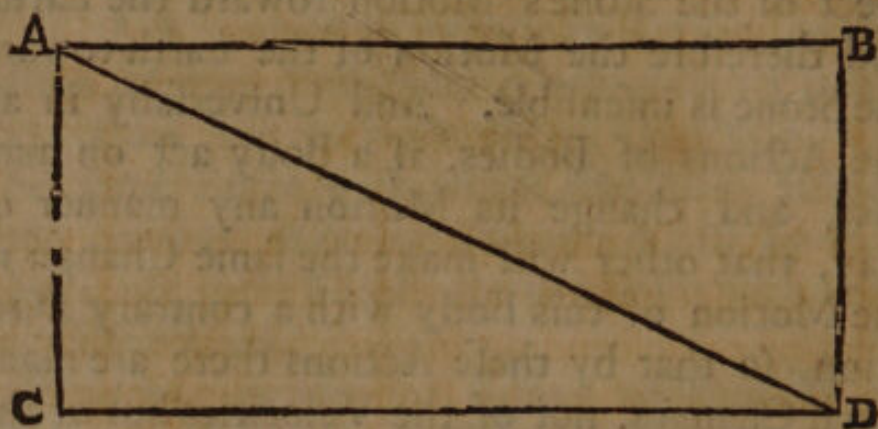
§ XV. **R**EPULSE or Reaction is always equal to Impulse or Action, or the Action of two Bodies upon one another is always equal, but with a contrary Direction, *i. e.* The same Force with which one Body strikes upon another, is return'd upon the first by that other; but these Forces are impress'd with contrary Directions.

Whatever presses or draws another, is as much press'd or drawn by that other; if one presses a Stone with his Finger, the Stone presses his Finger again. If a Horse draw forward a Stone by a Rope, the Stone does equally draw back the Horse, for the Rope being equally distended both ways, act upon both equally. If one strike an Anvil with a Hammer, the Anvil strikes the Hammer with equal Force. The Steel draws the Magnet as much as the Magnet does the Steel, as is evident by making both swim in Water; so in pulling a Barge to Land by a Rope, the Bank pulls the Barge as much as the Barge does the Bank; and in the descent of heavy Bodies, the Stone attracts the Earth as much as the Earth does the Stone; *i. e.* the  
Earth

Earth gravitates toward the Stone, as much as the Stone does toward the Earth. And the Motions produc'd by both these Gravitations, are equal in both, only the Stone is altogether inconsiderable, in respect of the Bulk of the Earth, and consequently the Velocity of the Earth's Motion toward the Stone is inconsiderable, in respect of the Stone's Motion toward the Earth, and therefore the Motion of the Earth toward the Stone is insensible. And Universally in all the Actions of Bodies, if a Body act on another, and change its Motion any manner of way, that other will make the same Change in the Motion of this Body with a contrary Direction, so that by these Actions there are made equal Changes, not of the Velocities but of the Motion, for the Changes made on the Velocities in contrary Directions, are in a reciprocal proportion to the Bodies.

## Corollary 1.

§ XVI. If a Body  $A$ , be impell'd by two different Forces, one in the Direction  $AB$ , with the Velocity  $M$ ; another in the Direction  $AC$ ,



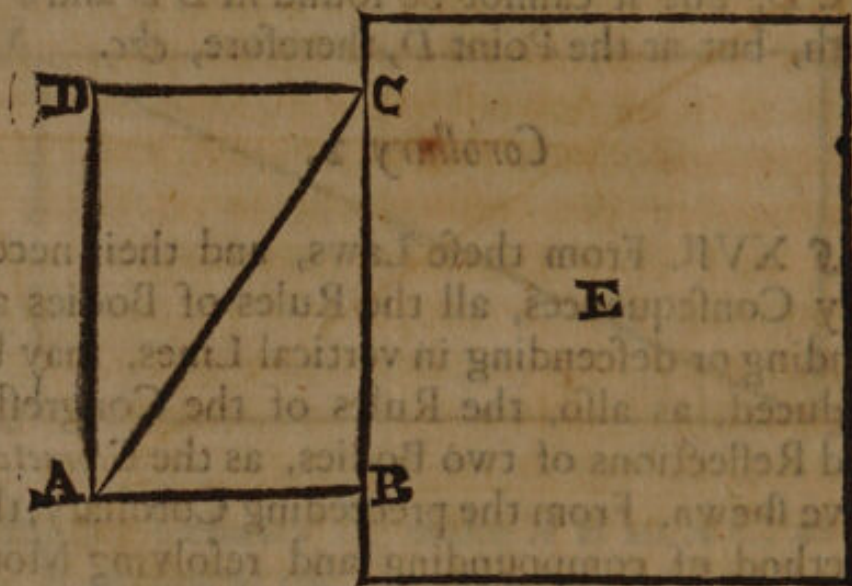
with the Velocity  $N$ , make  $AB$  to  $AC$ , as  $M$  to  $N$  complet the Paralelogram  $ABCD$ , the Diagonal of which is  $AD$ . The Composition of both these Forces will make the Body describe the Diagonal  $AD$ , and in the same time as it would have described either of the Sides; for because the Force, whose Velocity is  $N$ , acts in the Direction  $AC$ , parallel to  $BD$ , it will not in the least hinder or destroy the Velocity in the other Force, by which it tends to the Line  $BD$ . Wherefore the Body will reach  $BD$  in the same time, whether the Force, whose Velocity is  $N$ , be impress'd or not, and therefore in the end of this time it must be found some-

somewhere in  $BD$ , in like manner, the Force, whose Velocity is as  $M$ , acts in the Direction  $AB$ , parallel to  $CD$ , and therefore will not hinder the Velocity in the other Force in proceeding to  $CD$ , and the Body will reach  $CD$  in the same time, whether the Force, whose Velocity is  $M$ , act or not, and consequently, in the end of the same time, it must be somewhere in  $CD$ , but it cannot be found in  $BD$  and  $CD$  both, but at the Point  $D$ , therefore, &c.

Corollary 2.

§ XVII. From these Laws, and their necessary Consequences, all the Rules of Bodies ascending or descending in vertical Lines, may be deduced, as also, the Rules of the Congresses and Reflections of two Bodies, as the *Geometers* have shewn. From the preceding Corollary, the Method of compounding and resolving Motions in any given Directions may be drawn, for Example, (*see the former Figure*) the Composition of the direct Force  $AD$ , of any oblique ones, such as  $AB$  and  $BD$ , as also the Resolution of the direct Force, into any oblique ones, such as  $AB$  and  $BD$ , and likewise the *ratio* of an oblique Force to move a Body, to that of the same Force coming with a perpendicular Direction to move the same Body; for Example, (*see the following Figure*) let an oblique Force, as  $AC$  be impress'd upon the Body  $E$

in  $C$ , at the Point  $C$  erect a perpendicular  $CD$ , and from  $A$  let fall a perpendicular upon  $CD$ , and another upon  $CB$ ; then by the former Corollary, the Force  $AC$  may be resolved into the two Forces  $AD$  and  $AB$ , of which only  $AB$  has any Energy to move the Body  $E$ ; wherefore the oblique Force as  $AC$  is to the same



Force coming with a perpendicular Direction, as  $AB$  to  $AC$ , or as the sine of the Angle of Incidence  $AB$  to the Radius  $AC$ . The same is true of the Energy of an oblique Stroke upon the Body  $E$ , to that of the same striking perpendicularly.

From the same preceding Corollary, it follows that if a Body  $A$  be impell'd or drawn by three different Forces in three different Directions  $AB$ ,  $AE$ ,  $AC$ , so that the Body yields

to

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to  $AD$ ; and therefore the Forces acting in the Directions  $AC$  and  $AE$ , and equipollent to the Force acting in the Direction,  $AD$  are to this Force acting in the Direction  $AD$ , as  $AC$ ,  $AE$ , or  $CD$  to  $AD$ , that is, if a Body be urg'd by three different equipollent Powers in the Directions  $AB$ ,  $AC$ ,  $AE$ , these three Forces shall be to one another as  $AD$ ,  $AC$ ,  $CD$  respectively, *q. e. d.* and this single Proposition is the Foundation of all the Mechanicks, as several *Geometers* have expressly shown; so that it is plain, these three Laws do virtually comprehend all the Rules of Mechanism, and consequently, if any appearance contradict these Laws, or their necessary Consequences, it is not to be Mechanically accounted for. So then in our future Inquiries, we have nothing to do to show any thing is Immechanical, or not according to the establish'd Laws of Nature; but clearly to evince, that it contradicts some of these Laws or their Corollaries.

C H A P. II.

*Of Attraction or Gravitation in Bodies, and an account of some of the Appearances of Nature, from this Principle and these Laws now established.*

§. XVIII. **H**AVING thus explain'd the Laws that uninterrupted *Nature* constantly pursues in bringing about her Purposes and Effects. I come in the next Place to apply these to the most simple, uniform and regular *Appearances* that have as yet been observ'd; and these are the Motions of the Celestial Bodies. Many repeated Observations, and almost every single *Appearance* of these Bodies, evidently demonstrate them to revolve in *Curve Lines*, and therefore by the 1st Law to be drawn out of their rectilinear Course, by some extrinsic Force acting on them. Let us then enquire how it comes about, that these Bodies do persevere in their Motions, and do constantly move round in the same Tracts, without making the least Deviation? Now, that can happen but one of these two ways, *viz.* Either by the Force of some *Celestial Fluid* (call'd a *Vortex*) which carries 'em about, or by some *Retentive Central Force* which hinders 'em from running out in *strait Lines*, when they are once put in Motion  
by

by the Fingers of him who fram'd this marvelous *Machin* of a World.

§ XIX. In order to account for the *Celestial* Appearances, *Des Cartes* supposes the Matter of this Universe to have been at first divided by Almighty God, into innumerable little equal Parts, each endow'd with an equal Degree of Motion, both about its own proper *Center*, and separately among themselves, so as to constitute a Fluid; as also that several Collections of these Parts, were endow'd with a Motion about different Points (at equal Distances) as common *Centers*, so as to compose different *Vortices*, and that these Parts being made round by such intestine Motions, did produce *Globules* of different Magnitudes, which he calls the Matter of his *second Element*; as also that the small Raspings and Filings of the Angular Points of these *Globules* driven violently many different ways, did make up the Matter of his *first Element*; and seeing there wou'd be more of this *first Element* than was sufficient to fill the Vacuities between the *Globules* of the *second Element*, he supposes that the remaining part wou'd be driven toward the *Centers* of the *Vortices*, by the Circular Motion of these *Globules*, which did for that reason recede from it; and being there amass'd in a Sphere, wou'd in the *Center* of every *Vortex* produce a Body like the *Sun*; that the *Sun* being thus fram'd, and moving about its own *Axe* with the Motion of the rest  
of

of the Matter of the *Vortex*, wou'd necessarily throw out some Parts of its Matter through the Vacuities of the *Globules* of the *second Element*, which constitute the *Vortex*, especially at these Places which are distant from its *Poles*, receiving by these *Poles* as much as it loses about the *Ecliptick*, and by this wou'd be able to carry round with it these *Globules* which are nearest, with the greatest Velocity, and the remoter with a less; and that so of necessity these *Globules* that are nearest the *Center* of the *Sun* would be least, for were they greater or equal, they wou'd by reason of their Velocity, have a greater centrifugal Force, and therefore recede from the *Center*. Now shou'd it happen that any of these *Sun-like* Bodies in the *Centers* of the several *Vortices* shou'd be so incrustated and weaken'd, as to be carried about in the *Vortex* of the true *Sun*, if it were of less Solidity, or less capable of Motion than the *Globules*, towards the extremity of the *Solar Vortex*, then it wou'd descend toward the *Sun*, till it met with *Globules* of the same Solidity, and capable of the same Degree of Motion with it, and being fixt there, it wou'd for ever be carried about by the Motion of the *Vortex*, without either approaching to, or receding from the *Sun*, and so become a *Planet*. Supposing this true then, we may imagine our *System* to have been at first divided into several *Vortices*, in the *Center* of which was a lucid spherical Body,  
and

and that some of these being gradually incru-  
 stated, were swallow'd up by others, more  
 powerful and bigger, till at last they were all  
 destroyed and carried away by the biggest *Solar*  
*Vortex*, except some few that were thrown off  
 in right Lines from one *Vortex* to another, and  
 became *Comets*. Hence it appears according to  
 this *System*, that the *Planets* that are nearest the  
*Sun*, are least solid, which is *Des Cartes's* Rea-  
 son, why the *Moon* shows always the same Face  
 to us, because that *Hemisphere* that is opposite  
 to the *Earth*, is somewhat more solid than the  
 other. As also that the Matter of the *first Ele-*  
*ment*, which makes up the Body of the *Sun*,  
 moves with greater Velocity the Parts of the  
*Vortex*, and the Bodies swimming therein, that  
 are nearest it, than those that are remoter,  
 which is the Reason why the *Planets* next the  
*Sun*, finish their Periods sooner than those that  
 are more remote; and that these *Planets* move  
 about their own *Axes*, because they were *Sun-*  
*like*, lucid, and revolving Bodies before.

§ XX. Now not to mention the many De-  
 fects in the Mechanical Production of this ima-  
 ginary *System*, I shall only take Notice of  
 the known *Celestial* Appearances it contradicts;  
 and the Absurdities wou'd follow, tho' we shou'd  
 allow the Author all that he wou'd have grant-  
 ed. And, 1. It is certain that a *Vortex* produc'd  
 by the Revolution of a *Sphere*, about a giv'n  
*Axis*, wou'd be propagated *in infinitum*, if no-  
 thing

thing did hinder it; and seeing there must be as many such *Vortices* as there are fixt Stars, one *Vortex* wou'd necessarily run into another, and every Particle wou'd be acted by a Motion compounded, of the Motions of all the *Central Spheres*, which is absurd, and contrary to that Constancy and Limitation observable in the Celestial Appearances. 2. Since the Motion of the Parts of the *Vortices* nearest the *Center* is swifter than that of the more remote, they will press upon the exterior Parts, and thereby perpetually communicate some part of their Motion to them, and therefore these interior Parts of the *Vortex*, will be continually losing some part of their Motion, which never being restored, these Parts must gradually move slower, till at last the Motion is quite destroy'd. 3. According to this *Hypothesis*, each *Planet* is of the same Density with the Parts of the *Vortex* in which it swims, and is govern'd by the same Laws of Motion, and is, as it were, only concreted Parts of the *Vortex*: Now the times of the periodical Motion of Bodies, carry'd about by a *Vortex*, are in a duplicate proportion of the Distances from the *Center*; whereas the Squares of Times of the periodical Motions of the *Planets*, are as the Cubes of the Distances from the *Center*, and consequently the *Planets* cannot be carry'd about by a *Vortex*. 4. If a *Vortex* run out *in infinitum*, then a Body carry'd round by it, wou'd certainly describe a  
perfect

perfect Circle, unless something solid did hinder it, and therefore, the greater Distance there were between these solid Bounds, or the larger the Basin were which contains the *Vortex*, in respect of the *Orbit* of the Body carried about in it, the nearer wou'd this *Orbit* approach to a Circle, *i. e.* The Excentricity of the *Planets* nearest the *Sun*, would be less than that of those more remote, the contrary of which is true, for that of *Mercury* is greater than that of *Saturn*. Moreover, since the *Planets* in this *Vortex* wou'd necessarily move in *Orbits* nearly similar to that of the sides of the containing Basin. it wou'd follow that the *Aphelia* of all the *Planets* seen from the *Sun*, wou'd be directed towards the same fixt Stars: but this too is contrary to Observation. Likewise the Matter of the *Vortex* (as of every Fluid) when bound up within strait Bounds, must necessarily move faster than when enlarg'd in a wider Channel; *i. e.* The *Sun* seen from the Earth, must seem to move faster in the beginning of *Virgo*, than in the beginning of *Pisces*, which contradicts Experience. 5. A Body carry'd about in a *Vortex* of the same density with it, wou'd necessarily describe a Circle to whose Plane, the Axis of the central Body which produces the Circulation of the Fluid, wou'd be perpendicular; but there is not one *Planet* to the Plane of whose *Orbit* the *Sun's* Axis is perpendicular. Lastly, The *Comets* have their *Orbits*, not only oblique, but

but sometimes at right Angles with the Plane of the Ecliptick, sometimes the Course of these *Comets* is Diametrically opposite to that of the *Sun*; they persevere in their Motions without any change, they describe equal *Area's* by a *Radius* from the *Sun* in equal times, they enter into the *Vortex* of the *Sun*, all which is impossible, if the *Solar Vortex* mov'd round with Force sufficient to carry these vast Bodies of the *Planets* along with it.

§ XXI. This *Hypothesis* is somewhat altered and mended by the famous Mr. *Leibnitz*, he accommodates it better to the Celestial Appearances, and makes it agree more exactly to the Rules of *Geometry*. He first of all shows, that all Bodies which in a Fluid describe a *Curve-Line*, are mov'd by the Fluid, for of themselves they wou'd describe right Lines, and nothing but the Fluid concurs to turn them out of their way. He next shows, that every *Planet* is carry'd about by a Motion compounded of two other Motions, *viz* an *Harmonical Circulation* of the carrying Fluid, and a *Paracentrical Motion* of access to, or recess from the *Sun*. For understanding these Terms, we must observe that the *Planets* describe *Area's* by a *Radius* from the *Sun*, proportional to their times. Now the Fluid that carries the *Planets*, must of necessity circulate so as to produce this effect, which cannot be done otherwise, than by supposing innumerable concentrical Orbs of exceeding thinness

thinness to make up the *Vortex*, every one of which has its own proper way of Circulation, *viz.* those Orbs that are nearest the *Sun* circulate fastest, and the Velocities of the Circulations are every where reciprocally proportional to the Distances of the respective Orbs from the *Sun*, which will necessarily make the *Planet* in whatever part of *Vortex* it is, describe equal *Area's* in equal Times; for these *Area's* are in a compounded proportion of their *Radii* or Distances from the *Sun*, and a reciprocal proportion of the Arches or Lengths of the Circulations, which in this case will make a proportion of equality, and this Law of Circulation of the *Vortex* he calls *Harmonical*. The *Paracentrical* Motion is compounded of two others, *viz.* the *Excussory* Impression of the *Harmonical* Circulation, whereby all Bodies moving in a *Curve*, endeavour to recede from the *Center* by the *Tangent*, and the Attraction of the *Sun* or the Gravitation of the *Planet* toward it; and this Mr. *Leibnitz* is of Opinion, arises from an Impulse communicated by the Circulating Fluid. Now since the *Planets* move in *Elliptick* Orbits, in one of whose *foci* the *Sun* is, and by a *Radius* from the *Sun* describe equal *Area's* in equal Times, which no other Law of a Circulating Fluid, but the *Harmonical* Circulation can account for, we must find out a Law for the *Paracentrical* Motion, that may make the Orbits *Elliptick*. The *Excussory* Impression of the Circulating

culating Fluid, wou'd throw off the *Planet* from the Center by the *Tangent*. Wherefore the Attraction of the *Sun*, or the Gravitation of the *Planets* towards it, must be sufficient to destroy this Effect; and besides, to make them move in *Elliptick* Orbits, which cannot be brought about, unless this Attraction or Gravitation be reciprocally as the Squares of the Distances from the *Focus*, which is the Sum of *Leibnitz's* Doctrine upon this Head.

§ XXII. But even this Account of the Celestial Motions is both precarious and insufficient, for these Reasons. 1. The *Comets*, as was formerly said, have their Orbits, some of them very oblique, nay, sometimes at right Angles with the *Zodiak*, and sometimes the Courses of these *Comets* are quite contrary to that of the *Planets*: Now the *Comets* describing about the *Sun Area's*, proportional to the times, must be carry'd about by a *Harmonically* circulating Fluid, as well as the *Planets*, and thus we should have *Vortices* contrary to *Vortices*, which is very absurd. 2. This Supposition is not only unreasonable, but disagreeable to the uniform Simplicity of Nature: nor is there any thing in the Motions of the Heavenly Bodies so difficult to explain, as this very *Hypothesis*, which is introduc'd to account for them. Besides, 3. In equable Motion, the Times are always as the Spaces directly, and the Velocities reciprocally; but in a Circular Motion, the Spaces in one Re-

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volution

volution are as the *Radii*, and in an *Harmonical* Circulation, the Velocities are as the *Radii* reciprocally, and therefore the periodical Times of a Fluid circulating *Harmonically*, are in the Duplicate Proportion of the *Radii*. Now the periodical Times of the *Planets*, are in Sefquiduplicate Proportion, and not a Duplicate Proportion of the Distances from the *Center* or the *Radii*, and consequently the *Planets* cannot be carried about by an *Harmonically* circulating Fluid. To this it may be answer'd, that this *Harmonical* Circulation is not continued from *Mercury* to *Saturn*, but is interrupted, and reaches only from *Mercury's Perihelium* to his *Aphelium*, and there breaks off, and begins again at *Venus's Perihelium*, and reaches to her *Aphelium*, and is there again interrupted, and so on through the whole System of *Planets*: But what a ghastly and unsightly kind of Deformity there would happen on this Supposition? Every one may easily see, this is not like the uniform and simple Measures of Nature. Besides, the *Comets* moving forward in the *Zodiack*, pass through all these Chasms and Interstices, and notwithstanding, move in the same manner, as if they were carried by a Fluid, circulating *Harmonically* according to some uniform Law, neither do their Appearances shew the least Suspicion of these Interruptions.

§ XXIII. It being thus prov'd, that the Celestial Bodies do not revolve by the means of  
any

any circulating Fluid, they must be kept in their Orbits, by some *Attractive* Power in the *Sun*, or by some gravitating Power in them towards him, which is the same thing, since it must be mutual by the third Law. This Gravitating or Attracting Power of the great Bodies of the Universe towards one another, some *Philosophers* endeavour *Mechanically* to account for, from the Action of a Subtile Matter, which violently whirling round the *Sun* in general, the *Earth* and the rest of the *Planets* in particular, and acquiring thereby a Power of receding from the Center, impels Bodies towards that Center about which the strongest Circulation is made; or being driven with an immense Velocity in right Lines according to all possible Directions, impels the Body according to the Direction of that part of this Subtile Fluid, which is least resisted by the interposition of other Bodies. And thus, not only Bodies within the Sphere of the *Earth's* Activity are impell'd towards it, but also the *Planets* do gravitate towards the *Sun*, but without entering into the particular manner of the Explication of Gravitation according to this Scheme, there be two or three Objections against all the possible Accounts of Gravity in particular, or Gravitation in general from the Circulation of a Subtile Matter. 1. It is impossible from the first Part of this *Hypothesis*, to account for Bodies gravitating towards a Point, for the Motion *quaquà versum* in a great Circle

of the Sphere, which is alledged to solve this Difficulty, is a Contradiction to Nature, no such thing being either conceivable or possible. 2. It is impossible to explain whence the Circular Motion of this subtile Fluid comes, there must be conceiv'd another subtile Fluid moving after some certain manner to produce the Motion of that Fluid, which is the Cause of Gravity, and so on in *infinitum*, or else we must admit its Motion without any Cause, which is harder to conceive than Gravity it self. 3. That Matter which is the Cause of Gravity, or by whose Motion it is produc'd in all the possible *Mechanical* Explications thereof, must be without Gravity which is absurd, Matter being every where in reason to be suppos'd of the same uniform Nature, and its Gravity to be always proportional to the Quantity of its solid Mass. For since all the Bodies we can make Observations upon are heavy, as well as extended and impenetrable, it is reasonable to conclude so of all Bodies whatsoever, else all *Universal Properties* in Philosophy must be given up: And therefore it is Absurd to suppose there are some Portions of Matter without that Quality which every Portion of Matter we can make Observations on has. 4. Bodies from the Impulse of a Fluid can only gravitate in proportion to their Surfaces, and not according to their Quantity of Matter, which is contrary to Experience; for we find all Bodies gravitate in proportion to their  
their

their Solidities, *i. e.* their Quantity of Matter ; And tho' this Difficulty may be remov'd, by supposing Bodies to consist originally of *Cylinders* of infinitely small *Bases*, for on such a Supposition, these *Cylinders* wou'd be to one another as their Surfaces, their *Bases* being nothing, and consequently, the Gravities of Bodies, which by the Action of this subtle Fluid are as their Surfaces, wou'd be also as their Solidities, *i. e.* the Quantities of Matter they contain, since the Surfaces of the original Particles of Bodies are as their solid Contents. Yet this is so very hard a *Postulate*, to require Bodies to be diversified, only by the Lengths of their primitive constituent *Cylinders*, that I can't see how it can possibly account for all the varieties of Colours, Tastes and Smells, and other sensible Qualities of Bodies which arise from the Diversities of the Texture and Figure of their constituent Parts. But that which in my Opinion, overthrows all such *Mechanical* Accounts, however artfully contriv'd, is that, *v.* There seems to be necessary toward a full Explication of the Appearances of Nature, several different Conditions of this Universal Law of *Gravitation*, which cannot be *Mechanically* explain'd, without supposing different Systems of this Fluid, to move after different Manners, and according to different Laws, which will neither accord easily together, nor seem like the Limitations and Simplicity of Nature. That there are different

Conditions of the Universal Law of *Gravitation*, necessarily to be suppos'd, seems evident from the Nature of Light, as Sir *Isaac Newton* has explain'd it from certain Experiments; and there are other Appearances in Nature, that seem to require Conditions different from that which governs the Motions of the Celestial Bodies, and causes the inflexions of the Light, as shall be afterwards shown. Now, to account *Mechanically* for these different Conditions of the General Law of *Gravitation*, there must of necessity be suppos'd various and different Systems of this subtile Fluid, which looks a little odd, especially if we consider, that is not as yet known how many and how different these Systems must be suppos'd, to account for all the various Conditions of this General Law, that may hereafter be discovered necessary to explain the various Appearances of Nature. 6. Lastly, this whole Affair is more Naturally and Simply to be accounted for from Principles now to be laid down.

*Corollary.*

§ XXIV. From what has been said it appears that the Attraction or Gravitation of Bodies toward one another, is not to be *Mechanically* accounted for, and since it has been likewise shown, that the *Planets* cannot continue their Motions in their Orbits, without the Supposition of such  
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an Attraction or Gravitation, it is evident, that this must be a Principle impress'd on Matter by the *Creator* of the World ; it is a Principle no ways essential to Matter, since it is the Source and the Origin of the Celestial Motions, as *Sir Isaac Newton* has demonstrated. And by the first Law of Nature and its Corollaries, no kind of Motion is essential to Matter, and therefore Attraction or Gravitation cannot be essential to it ; it is not a Result from the Nature of Matter, because the efficacy of Matter is communicated by immediate Contact, and it can by no means act at a distance ; for we see an Object, because the Light reflected from thence strikes immediately upon our Organs of Vision, we smell, because parts of the odorous Body touch the Nerves of our *Nostrils*, and universally all the other Natural Effects of Material things are perform'd by the meer Impulse of one Body on another, whereas this Power of Gravitation acts at all Distances without any *Medium* or Instrument to convey it, and passes as far as the Limits (if any such there are) of the Universe. And acts, not like *Mechanical* Causes, according to the Quantity of the Surfaces of Bodies on which it acts, but in proportion to the Quantity of solid Matter which these Bodies contain. Besides, by the first Law of Nature, Matter is entirely passive in its Nature, and can no more tend to, or draw other Bodies than it can move of it self ; likewise supposing this Gravitation

of the parts of Matter toward one another destroy'd, yet still Matter wou'd be the same extended solid Substance. Moreover, if there were but one indivisible Part of Matter in being, it could not be said to have this Property, it being a Relative one, and having respect only to other Parts which it attracts; whereas Impenetrability or any other of the essential Properties of Matter continues with it, ev'n when it becomes indivisible. On the other Hand, if the whole Quantity of Matter now in being, were *amass'd* so together, that there were neither Motion nor Vacuities in it, (neither of which Suppositions imply a Contradiction; for if any two Particles of Matter can be so compacted as to admit no Vacuity between them, then it is no contradiction to suppose the whole *aggregat* of Matter so *amass'd*, and we are demonstrably certain, Motion is not essential to Matter) then the whole *Mass* would either be without this Quality of *Attraction*, or this Quality would be absolutely useless or without Effect, which is much the same thing in an active Quality, as this of *Attraction* is. Lastly, as Motion is in some Circumstances, the necessary Effect of gravity in Bodies, and in other Circumstances must have proceeded from an original Impression, (as in the *projectile* Motion of the *Planets* along their *Tangents*) and yet is of the same absolute Nature in both Cases, and certainly, is not *essential* to Matter; so *Attraction*

*Elion* or *Gravitation* is not *essential* to Matter, but seems rather an *original Impress* which continues in it, by virtue of the *Omnipotent* Activity, in the *Divine Nature* of which it is a *Copy* or *Image* in the low Degree that is suitable to a gross Creature, and so may now be reckon'd among the *primary* Qualities of Matter, without which, as it is now constituted Matter cannot be, but did not *Originally* belong to it as a *Materia prima*. On all which Accounts, its highly probable that this Universal Force of *Gravitation* is the effect of the *Divine Power* and *Virtue* originally impress'd on, and by that first *Energy* continued in Matter, by which the Activity and Operations of Material Agents are preserv'd. And this Power of *Gravitation* being thus impress'd on Matter, is one reason of the Distinction between the Laws of *Creation* and *Nature*, for tho' the *Energy* of that first Impression does still last, and is the Source and Spring of the *Uniformity* and Continuance of the *Celestial* Motions, yet its not being essential to Matter, nor arising from its Nature, is the reason why it ought not to be reckon'd among those Laws which arise from the particular Texture, Figure and Disposition of Bodies, such as most of the Laws of Nature or Motion are. The chief Difficulties that I can find have straitned Learned Men, in admitting this Principle of the Universal Law of the *Gravitation* of Bodies upon one another are, 1. That they cannot conceive how this Principle can be  
*Mechani*

*Mechanically* accounted for; and they think it *Unphilosophical* to admit any Principle in the Explication of the Appearances of Nature which can't be thus accounted for. It is indeed in my Opinion certain, that this Principle cannot be *Mechanically* accounted for; for there is no other *Mechanical Cause* conceivable, this Principle of the *Gravitation* of Bodies upon one another, can arise from, but the Motion of some subtile Fluid, and were there no other Argument against all possible Explications of *Gravitation* arising from the Motion of a subtile Fluid, but this one, *viz.* that thereby these Parts of Matter which are the Cause of, or produce *Gravitation*, are upon this Supposition, destitute of Gravity; I shou'd think it sufficient to prejudice any inquisitive Man against such Explications; for it's certain that Nature is uniform and consistent with it self, and wou'd not deprive one part of Matter of so Cardinal a Property, with which she had endow'd all the rest. The whole Foundation of *Natural Philosophy*, is *Simplicity* and *Analogy*, or a Simple, yet Beautiful *Harmony*, running through all Works of Nature in an uninterrupted Chain of Causes and Effects, with proper Limitations of Circumstances: And if these Principles be superseded, or this Chain broken, we can expect nothing but Absurdities and Inconsistences in *Philosophy*. But even the admission of such an *Hypothesis* removes us but one Step further from *Immechanical Principles*,

ciples, for the Cause of the Motion of this subtile Fluid, which is the Cause of Gravity, is it self *Immechanical*. Nor has any Body ever pretended to assign any other Cause of the Motion of this subtile Fluid, but the *Omnipotent Cause* of the *Universe*; and since we must of Necessity admit the Motion of this subtile Fluid, which is the Cause of *Gravitation* to be unaccountable without a *First Cause*, why may we not rather admit this *First Cause* to have impress'd this Property in Matter, since that this Difficulty is the same in both; and that besides, the first Supposition is burthen'd with several Additional ones, to which the second is not liable. There has never been any System of *Natural Philosophy* offered to the World as yet, that does not require some *Postulates* that are not to be accounted for *Mechanically*; the fewest any one pretends to, are the Existence of Matter, the Impression of Rectilinear Motions, and the preservation of the Faculties of Natural Agents, which no Man has pretended to account for from Principles of *Mechanism*; and the Impression of an *attractive Faculty* upon Matter, is no harder *Postulate* than any of these; but since it is Matter of Fact and Demonstration, that Matter is in possession of this Quality; for we daily see, that the Earth draws to its Center all Bodies within its Activity, we must allow of it, whether it be to be *Mechanically* accounted for or not; and since it is not to be accounted  
for

for from *Mechanical* Principles, as I think, I have demonstrated, we must of necessity refer it to the Power and Influence of the *First Cause* of all things. For Causes proceed in a continual *Chain*, from more complex to more simple Ones, and at last to the most Simple; and when we are arriv'd at that Cause, we can go no further, else that Cause would not be the most Simple; and this most simple Cause cannot be *Mechanically* explain'd whatsoever it may be, else it could not be the most Simple: And therefore since we must admit of *Immechanical* Causes, since *Gravity* is undeniably the Property of all the Bodies we can make Observations upon, and is sufficient to account for the *Appearances* of all those Bodies that revolve about us, as Sir *Isaac Newton* has shown, there can be no Reason for rejecting it, tho' it cannot be *Mechanically* explain'd. 2. Another Difficulty ingenious Men have in the Conception of this Quality in Matter, is, how it can act at a Distance without any *Medium* to convey this Action, as of necessity it must. Now, were there no other Difficulty of the like Nature in Philosophy but this one, it might stumble judicious Persons; but we know the manner of *Thinking* and *Reflection*, of *Remembring* and *Sensation*, are things not easily to be explain'd, and yet we must admit them. The Communication of Motion from one part of Matter to another, and ev'n the first Production of Matter and  
Motion,

Motion, are not to be accounted for, and yet there is no denying that such things really are, when we are capable to explain how our Souls and our Bodies act mutually upon one another, we may come to be able to conceive how Matter acts at a Distance without any *Medium*; but till then, it is sufficient to know, that such a Quality is actually lodg'd in Matter, and that it is the Cause of all the Great and Uniform Appearances of Nature. There is no Contradiction, in supposing that the same Effects may arise from Causes not altogether the same, but that only can be the true Cause from which the Effect truly proceeded. Other imaginary or *Hypothetical* Causes, have no place in true *Philosophy*. In *Clocks*, for Example, the Hand on the Dial-Plate, may be mov'd by a *Spring* or *Weight*; but if a particular *Watch* were propos'd, he wou'd say nothing to the Purpose, who shou'd explain all its Motions by a *Spring*; when upon looking within it, he might have found a *Weight* perpetuating the Motion of the Machin, which yet he cou'd not explain by Rules of *Mechanism*. No wise and honest Man, who throughly understands the Matter, will offer to explain by Rules of *Mechanism*, how this *System* of things was produc'd, nor how the Faculties of Material Organs are preserv'd, whence they arose, and what way they communicate their Actions and Influences to one another; it will suffice such, from the Present Appearances to investi-  
gate

gare the Powers and Forces of Nature, and from these to account for future Observations and Appearances ; if we admit an *infinitely Wise and Powerful Being* to have made this World, there will be little Difficulty in allowing him to have impress'd on Matter what property he pleas'd, and if we will not admit of such a Being, there are much greater and harder Difficulties in the *Mechanical* Explication of the Nature of things to be surmounted, as shall be afterwards shown.

No Body who is but tolerably acquainted with the most probable Discoveries in Natural *Philosophy*, can imagine these to reach any farther than some of the grosser *Lineaments*, or more conspicuous *Out-lines* of the Works of the *Almighty* ; since he must be very Ignorant, who can think to search *Him or his Works out*, to any tolerable degree of *Perfection*. *Simplicity* and *Harmony* are the surest Marks that the Discoveries made are of the true Kind, and *Analogy*, the best Rule to make them by. This is so evident in the Principle of *Attraction*, that I shall here, tho' not its most proper Place, observe a few *Hints* tending that way. God has most certainly implanted something *Analogous* to *Attraction*, in the greatest *Central* Body of each *System* towards the lesser ones of the same : Or, a Principle of *Gravitation* in these lesser ones towards the greatest *Central* one, and towards each other. From hence, and from  
their

their directly impress'd Motions, all their comely, regular and uniform Revolutions, Appearances and Actions upon one another spring. Thus it is in the great Bodies of the Universe. Something Analogous to this is the Spring and first Mover (at least acting in the Order of God and Nature it ought to be) of all the noble and regular Actions of spiritual Beings. God being the *sole sovereign, self-existent and independent* Being, when he made Creatures partaking of himself, Images, *Emanations, Effluxes* and Streams out of his own *Abyss of Being*, could not but impress upon their most *intimate* Natures and Substances, a *Central Tendency* toward Himself, an Essential Principle of *Re-Union* with himself; which in him is a Principle of *Attraction* of them towards him, *Analogous* to this Principle now mention'd in the Great Bodies of the Universe. As well might we suppose an exquisite Artificer voluntarily producing a piece of Work which should be the Reverse of his own *Idea*: As well may the *Ray* be supposed *Dissimilar* to the Body of the *Sun*, or the *Stream* to the *Fountain-Head*; as that infinite Power and Perfection should produce a *spiritual* Creature, that had a necessary Tendency to *shun* or *fly* away from him, or even be in a state of Indifferency toward him. *Self-existence* and *infinite Power* must needs subject all Beings to it self, and infinite Perfecti

on must do it so, as must be most *congruous* to the Nature of the Creatures it produces, in order to make them as happy as they can be made; and therefore God could not make spiritual Creatures, but he must implant the Principle of *Re-union* in them, in order to bring them back to himself, that is, to make them happy: This is the *Origin* of Natural *Probity* and *Conscience*. It is true, this Principle may be, and in most actually is, buried under Matter and Sensuality; extinguish'd, as it were, by the more powerful *Attractions* of present sensible Objects, the Allurements of Carnal Enjoyments, and the violent *Distractions* of the Pleasures of this World; so that it is not easily perceiv'd, but by those who have for some time faithfully follow'd its Direction and *Drawings*. But it is no less an essential Principle in a *spiritual Creature*, tho' thus stifled and oppress'd, than the Rational Soul is of an *Idiot*, tho' its Operations and Evidence be hindred and obstructed thro' the inept Organisation of its Body. This Principle of *Re-union* in *spiritual* Beings, whenever disentangled, unfolded, attended to, and regularly follow'd, will as infallibly lead these to their proper *Center* of Light and Bliss, and unite them for ever with it, as the Sun's *Attraction* will bring about the Seasons and Changes of the Year. On the other hand, if this Principle have not its *Energy* in this Life,  
when

when ever the Charms and *Attractions* of Sense cease, the acquired Principle of *Dissimilarity* must repel these Beings with infinite Force from their Centre, so that the Principle of *Re-union* being set free by Death, and disintangled, and acting constantly, because Essential, must drive these Beings towards God their *Original Centre*, and the Principle of *Dissimilarity* repelling them, or forcing him to repel them with infinite Violence from him, must of necessity make them infinitely Miserable. Thus the future Happiness or Misery of *spiritual Creatures*, depends on this Principle of *Re-union*, as indeed their present does likewise; for whatever is in the order of its Nature, that is of God, its Origin, must be Happy, since he is so; and whatever is in a violent or unnatural State, that is, in a State opposite to God and Happiness, must be in Misery. As the Planets disturb'd by no other *Attractions*, but from their *Central Orb* of Light, and one another, revolve in comely Order and beautiful Harmony, shedding their benign Influences on one another: So *spiritual Creatures*, following the *Drawings* of the luminous Centre of their Being, and giving themselves up to the Direction of their innate Principle of *Re-union*, enjoy the whole Felicity of their Natures in their present State, advance in Purity and Perfection, and in mutual Benevolence and good Will towards one another. For as Motion is the necessary Consequence of *At-*

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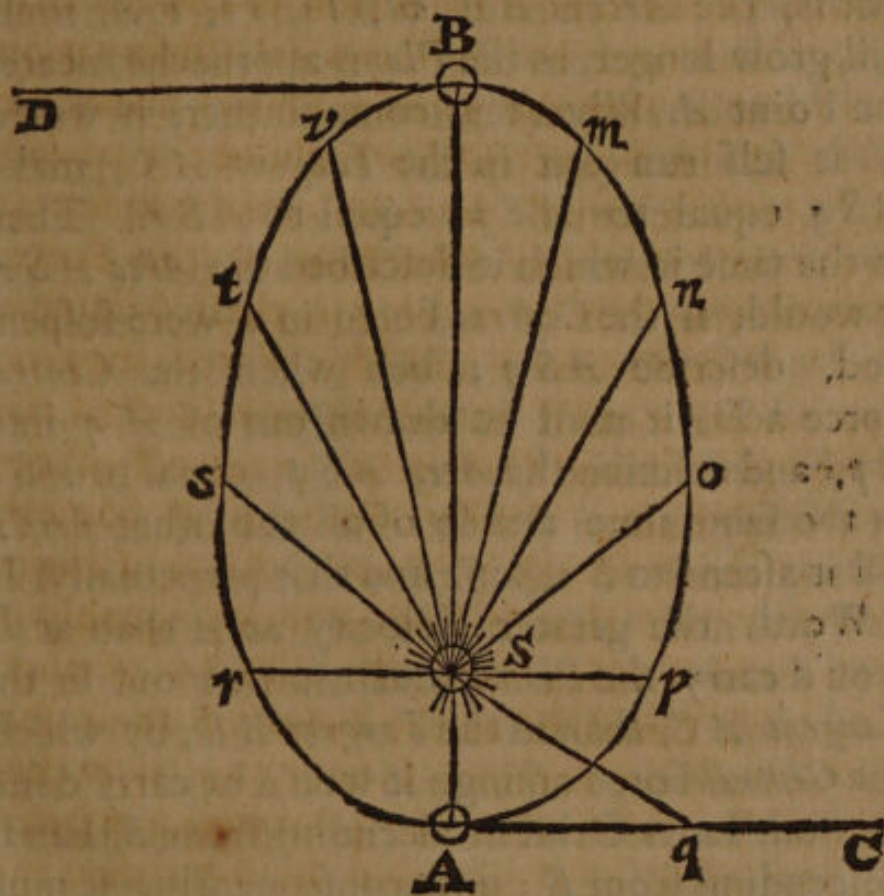
*traction*

*traction* in Bodies that have nothing resisting them from without, so *Love* and *Benevolence* towards their great *Origin*, and towards one another, is the necessary Effect of this Principle of *Re-union* in free Creatures, when unfolded. As the *Vapours*, and even the *Planets* are purified by the *Sun*, and in some Sense made *similar* to, and converted into his Substance, by being rais'd nearer to his glorious Body: So *spiritual Creatures* are yet more refined, *spiritualized*, and made liker the *Deity*, the nearer they approach to the Fountain of Purity and Perfection, by faithfully following his *Attractions*: which too, like the *Suns*, are powerful and vigorous; infuse Light and Strength, tho' not sensible. In a Word, as the *Attraction* of the *Sun* on the *Planets*, makes them first move, and then describe regular *Orbits*, so this Divine *Attraction* in spiritual Beings, animates the Will, and actuates the Affections, and these do all the rest that is to be done in this present State: And as the discordant *Attraction* of some wandering *Comets* wou'd certainly distract and disorder the *Harmony* of the Motions and Revolutions of the *Planets*, if they approach'd too near them; so gross irregular carnal Affections, earthly and sensual *Attractions* admitted too nigh, disturb and destroy the beautiful Progress of *spiritual Beings*, towards the Centre and End of their Being. *Vide* Cap. 2. Part 2.

§ XXV. The great and primary *Law* then, imprinted by the Author of Nature upon all the Bodies of this Universe, is that every part of every Body attracts every part of every other Body; and the most general Conditions of this Law are, that the *Force* by which one part attracts another in different Distances from it, is reciprocally as the Squares of those Distances; and that at the same Distance, the *Force* of the Attraction or Gravitation of one part toward divers others, is as the Quantity of Matter they contain: By the Virtue and Efficacy of this Law, the *Planets* must perpetually move in *Elliptick* Orbits, if they meet with no resistance in the Spaces in which they move. For since it has been observ'd, that all Bodies persevere in their state of rest, or moving uniformly in a streight Line, but in so far as they are forc'd out of this State, by some *foreign Violence* impress'd on them; it follows from thence, that Bodies which move in *Curve* Lines, and which are therefore forc'd out of their streight Course, which would have been the *Tangents* of these Curves, must needs be retain'd in these *Curve* Orbits, by some *foreign Violence* perpetually acting on them. The *Planets* therefore which revolve in *Curve* Orbits (because returning again in the same Tract perpetually) must necessarily have some *foreign Violence* perpetually acting on them, by whose Influence they are drawn out of their *Tangents*.

Moreover, since it is demonstrated, (*Prop. 2. Lib. I. Princip. Phil. Newtoni.*) that Bodies, which move in a *Curve*, on a *Plane*, and by a *Line* drawn from them to a *Point*, fixt, or however moved, describe about that *Point* *Area's* proportional to their times; are urged or drawn by a *Force* tending to, or whose *Direction* is toward that *Point*; and since by *Astronomical* Observation it is certain, that the *primary Planets* about the *Sun*, and the *secondary Planets* about the *primary Ones*, describe equal *Area's* in equal times. It is evident, that the *Direction* of the *Force*, whereby the *Planets* revolve in their *Orbits*, is toward their *Centers*: and this *Force* may be very properly call'd *Attractive* in respect of the *Central Body*; and *Centripetal*, in respect of the revolving *Body*. Lastly, Since it is likewise demonstrated, (*Coroll 6 Prop. 4. Lib. I. Princip. Phil. Newtoni.*) that if Bodies move equably in *Concentrick* *Circles*, and the *Squares* of their periodical *Times* be as the *Cubes* of their *Distances* from the common *Center*; or, if Bodies revolve in *Orbits* that are pretty near *Circles*, and the *Aspids* of these *Orbits* be fixt: then the *Centripetal* *Forces* of those *Bodies*, will be reciprocally as the *Squares* of the *Distances*. And that the *One* of these *Cases*, or the *Other*, is *Fact*, is universally acknowledged by all *Astronomers*: and consequently the *Centripetal* *Forces* of the *Planets*, are as the *Squares* of their *Distances*. Now that we may have a general *View*,  
how

how a *Planet* by the same Law, can be made approach to, and recede from the *Attractive* Central Body, which seems the greatest Difficulty in this Case; let us consider the following *Scheme*, wherein let *S* represent the Sun, *Ao Bs*, the Orbit of a Planet *B*, descending from *B* to *A*. Let the time of its Revolution



be divided into equal Parts, and then they will be represented by the equal *Area's* which are supposed to be described by the Line *B S*, drawn through the Body of the *Planet B*, to the Sun *S* in its several Stops; *v, t, s, r, A* and

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these

these *Area's* will be the *Triangles*  $BSv$ ,  $vSt$ ,  $tSs$ ,  $sSr$ ,  $rSA$ . Now since the *Attraction* in  $S$  encreases reciprocally as the *Squares* of the *Distances*, the *Velocities* of the *Planet* in its descending towards the *Sun*, must be encreased by the encreasing *Central Force* on it, which must make the *Bases* of these *Triangles* larger, that is, the *Arches*  $Bv$ ,  $vt$ ,  $ts$ ,  $sr$ ,  $rA$ , must still grow longer, as the *Planet* approaches nearer the *Point A*. When it is come thither, it wou'd of it self run out in the *Tangent AC*, make  $ASq$  equal to  $ASp$ , equal to  $ASr$ . Then in the time in which it described the *Area*  $ASr$ , it would, if the *Central Force* in  $S$  were suspended, describe  $ASq$ ; but when the *Central Force* acts, it must be drawn out of  $Aq$  into  $Ap$ , and describe the *Area*  $ASp$ , equal to  $ASq$  in the same time, and so of all the other *Area's*, till it ascend to  $B$  again, and that perpetually. In a *Word*, the greater *Velocity* at  $A$  than at  $B$ , wou'd carry the *Planet* much further out in the *Tangent AC*, than in the *Tangent BD*, by which, the *Central Force* acting, it wou'd be carry'd further out in its *Orbit* in ascending from  $A$ , than in descending from  $B$ ; and consequently, it must approach to  $S$  in descending from  $B$ , and recede from  $S$  in ascending from  $A$ . By *Virtue* of the same *Law*, and of these *Conditions*, the *Moon* will for ever turn round the *Earth*, as the *Earth* doth round the *Sun*, and the *Satellites* of *Saturn* and *Jupiter* round them; as also the *Co-*

*met*s will in very oblong *Elliptick* Orbits describe about the *Sun* equal *Area's* in equal times; but because the *Sun*, not only attracts the *Planets* and *Comets*, but also these the *Sun*, and likewise the *Planets* attract one another, their Orbits will be somewhat irregular, and differ from exact *Ellipses*, which will be more sensible in the Motions of the *Moon*, because She is so near to us; and this one Consideration well apply'd, will account for all the Irregularities hitherto observ'd in the Celestial Appearances, as Sir *Isaac Newton* has shown; likewise, since a great part of this our Globe is covered over with Water, it is plain, that by the joint Force of the Attraction of the *Sun* and *Moon*, the Water that lyes directly under them, will be rais'd above its ordinary Level, which will likewise happen if they are directly in the opposite part of our Globe, because the remoter parts of the Water will be less attracted than the nearer, and the Motions produc'd in the Waters by the Attraction of these two *Luminaries* can't be observ'd separately, but their Forces make up a compound Motion, which at New and Full *Moon* is greatest, and least at the *Quadratures*, and these effects are variously limited by the different Distances of these *Luminaries* from the Earth, their *Declinations* from the *Æquator*, the various *Latitudes* of Places, and also the different Situation of the *Shores*, *Banks* and *Bays* of the *Sea*. By this Gravitation, Bodies

on this Globe will press towards its Center, tho' not exactly thither neither, by reason of the *oblate spheroidical* Figure of the Earth arising from its diurnal Rotation about its Axis. Thus we see this one Principle will account for all the great and constant Appearances of Nature, and none but this will exactly answer any one, much less them all, which is a Demonstration of its Truth. And were not our Terrestrial *Physiology* more complicated than the Celestial, (by reason of the multiplicity of different Attractions proceeding from the many different Bodies that surround any particular one) we should doubtless see the Extent of this Principle, in accounting for the more minute, and less constant appearances on this our Globe, as in a great many we actually are. Add to these Considerations, that we are certain by the Effects, that the Gravitation by which the *Planets* are kept in their Orbits, and by which the *Moon* turns round the Earth, is of the same Nature with that by which heavy Bodies tend toward the Center of the Earth. In the *Moon* the Case is plain, for since the *Rectilinear* Spaces, describ'd by falling Bodies in the beginnings of their Motions, from whatever Motive Powers they be urg'd or drawn, are *proportional* to these Powers. The *Centripetal* Forces of the *Moon* revolving in its *Orbit*, will be to the Force of Gravity on the Surface of the Earth, as the Space the *Moon* describes in descending towards  
the

the Earth, by its *Centripetal* Force, in a small portion of time, if it were suppos'd depriv'd then of *Circular* Motion, to the Space, a heavy Body wou'd describe in the same time by its own Gravity, near the Surface of the Earth. The first of these Spaces, is equal to the *versed Sine* of the *Arch* describ'd by the *Moon* in that time, for that is the Measure of the Translation of the *Moon* out of its *Tangent*, by this *Centripetal* Power, which may be computed from the time of its *Periodical* Revolution, and its Distance from the *Center* of the Earth being given. The other Space is evident from the Experiments on *Pendulum's*; and when the just Calculation is made from these Principles, the first Space to the second, or the *Centripetal* Force of the *Moon* revolving in its Orbit, to the Force of Gravity on the Surface of the Earth, will be found as the *Square* of the *Semidiameter* of the Earth, to the *Square* of the *Semidiameter* of the *Moon's* Orbit. But in the former part of the Section it has been shown, that the *Centripetal* Force of all the *Planets*, was reciprocally as the *Squares* of their Distances. Therefore the *Centripetal* Force of the *Moon* near the Earth's Surface, is equal to the Force of Gravity, and consequently it is the same Force in both; for were they different Forces, Bodies by the united Forces of the *Moon* and Earth, wou'd fall with double the Velocity they now do: It is plain then, that the *Centripetal* Force  
whereby

whereby the *Moon* is drawn out of its *Tangent*, is the very same Terrestrial Gravity (whereby Bodies descend near the Earth,) which reaches to the *Moon*; and since the Revolutions of the *primary Planets* about the *Sun*, and of the *secondary Planets* about their primary Ones, are Appearances of the same Nature with that of the *Moon* about the Earth, since it has been shown that the *Centripetal* Forces of the *primary Planets* are directed towards the *Sun*, and the *Centripetal* Forces of the *secondary Planets* towards their primary Ones, as the *Moon's* is towards the Earth; Lastly, Since all their *Centripetal* Forces are reciprocally as the Squares of their Distances, we must conclude the Natures of their Gravitation to be the same in them all, and that they all Gravitate towards one another. For since Action and Reaction is mutual, and since the *primary Planets* gravitate towards the *Sun*, as also the *secondary Planets* tend toward the Primary ones as the Center of their Motions; and since the Decrease and Increase of this Gravitation, is of the same Nature with that of our Terrestrial Gravity; since likewise the *Sun* disturbs the Motion of the *Moon*, and the *Sun* and *Moon* those of our *Earth*, it is plain they all, *Sun*, *Moon*, *Planets* and their *Satellites*, mutually gravitate upon one another.

§ XXVI. Having thus in the General, establish'd the *Laws of Nature*, and deduc'd such Consequences from 'em as we found necessary

to clear some Parts of the following Discourses; having likewise shown the Necessity of admitting the Universal Law of *Gravitation* to solve the Celestial Appearances, and hinted the great Use of this Principle in the Celestial *Physiology*, let us next proceed to some of the most *Universal* of our Terrestrial *Phænomena*; and first of all, let us enquire into the Nature and Cause of Fluidity, which seems to consist principally in the *Mobility* of some parts, without carrying along with 'em the rest, or the easie slipping of some Parts upon others unmov'd, at least, not mov'd after the manner of solid Bodies. All the Bodies in the Universe are Originally compounded of solid Parts, tho' not indivisible, yet very small and firm; and Fluids must necessary take in these four Conditions. 1. That their Parts be extremely little; in our common Fluids it is certain that no Eye, however assisted, has been able to perceive their Magnitude; we have been able to discover the Figures of Bodies swimming in Fluids, but no one as yet has been able to distinguish the *Figures* or *Magnitudes* of the constituent Parts of *Liquors*. 2. That their Figures be *spherical*, or at least *spheroidical* or approaching to one of these, so that they may touch only in a Point, and by consequence, one Particle may easily slip upon another, and for that End, 3. They must be exactly smooth and polish'd, and subjected to the Universal Law of  
Gravita-

Gravitation, whereby each Particle of the Fluid attracts another, whence that cohesion in the Parts of the finest natural Fluids proceeds; but their Gravity must be such, that the Force thereof may easily exceed the Force of their Cohesion; and here we are to distinguish between these Fluids, generated by the Force of the Fire, and those that are naturally such, there being no necessity of attributing any particular Figure to the Parts of the first Kind, which owe their Fluidity to the Force of the Particles of Fire, which tear asunder the Parts of solid Bodies, and keep 'em in a perpetual Agitation, and thereby make 'em appear in the Form of a Fluid; whereas the Appearances of natural Fluids do necessarily require the Conditions in their Parts just now assign'd.

4. The Particles of natural Fluids must be similar, of equal *Diameters*, of equal Solidity, and consequently of equal specifick Gravities, or at least they must not widely differ one from another in these Qualities, that the Fluid may be *Homogeneous*, and of the same uniform Nature; from these general Suppositions, all the general Appearances may be easily accounted for.

§ XXVII. Water seems to consist of small, smooth, hard, porous, spherical Particles of equal *Diameters*, and equal specifick Gravities, which have between 'em some Spaces so large, and ranged in such a manner, as to be pervious on all

all Sides. Their Smoothness makes 'em slip easily upon one another ; their *Sphericity* keeps 'em from touching one another in more Points than one, by both which, their Frictions in sliding upon one another is rendered the least possible ; their Hardness is the reason why Water is incompressible, when the Air lodg'd in it is exhausted.

§ XXVIII. The *Porosity* of the Particles of Water (which is so great, that a *Cubical* measure of Water contains at least forty times more Pores than Parts ; for Water is nineteen times lighter than Gold, and consequently nineteen times rarer than Gold ; and Gold will by much pressure, let Water pass through it, and so may be supposed to have more Pores than solid Parts) accounts not only for the different *Specifick* Gravity between Water and other Fluids, such as *Mercury* ; but also for its greater Transparency than most other Fluids, the *Rays* of Light finding an easy admittance on all Hands through its pervious Pores, and it suggests the Reason also why it is more easily concreted into a solid Form than other Fluids are. *Cold* and *Freezing*, seem to proceed from some *Salin* Substance floating in the Air ; we see that all Salts, but more eminently some, mix'd with Ice, prodigiously encrease the Effects and Force of Cold, we see all *Salin* Bodies produce a Rigidity and Stiffness in the Parts of Bodies to which they are apply'd, much like the Effects of Freezing ;  
we

we know from Mr. Boyle's *History of Cold*, that Freezing increases the Dimensions both of Solid and Fluid Bodies; *Microscopical Observations* inform us, that the Figures of some Salts, before they shoot into Masses, are thin double wedg'd-like Particles, which have abundance of Surfaces in respect of their Solidity, which is the reason why they swim in Water when they are rais'd once, tho' they be specifically heavier. But this Effect may be more justly attributed to the same Cause that is presently to be shown to be the Cause of Freezing, *viz.* to the small Points of the Salts getting into the Pores of the Particles of Water, whereby these Salts are suspended in the Water. In Summer, the Heat of the Sun dissolves the *salin* Particles into a Fluid, breaks off their slender Points, and by its Action, keeps 'em in a perpetual Motion, so that they cannot shoot into a solid Wedge, and consequently are not able to produce the *Appearances* of Cold upon Bodies; but in Winter they are less disturb'd, and more at liberty to approach one another; and by shooting into those *Chrystals* (as we see the Particles of artificial Salts do, when the Liquor is expos'd to the Air) which by both their Extremities, insinuating themselves into the Pores of Particles of Water, make 'em cohere, and fix 'em in a solid Form. The Dimensions of freez'd Bodies are encreas'd by the Insinuations of these *Crystal* Wedges in their Pores, and the  
Particles

Particles of congeal'd Water are kept at some distance from one another, by the Figure of these *Chrystals*, which in Freezing, insinuate themselves in their Pores; for as I have before said, these *Chrystals* are observ'd to have the Form of a double Wedge, whose Extremities are pointed and slender, but its Middle broader and larger, so that when the Extremities have insinuated themselves into the Pores of two watery Particles, these *Globules* cannot come to touch, by reason of the Largeness of the Middle of these *Chrystals*, and so these Particles in Freezing, are kept at greater Distances from one another, than they were when in a fluid Form; and thus the Spaces between these spherical Particles, become larger and wider than before, which is one Reason why Ice becomes *specifically* lighter than Water. But besides this, there are many little *Volumes* of Air included at several Distances, both in the Pores of the watery Particles, and in the Interstices form'd by their spherical Figures. Now by the Insinuation of these *Chrystals*, the *Volumes* of Air are driv'n out of the watery Particles, and many of 'em uniting form larger *Volumes*, which thereby have a greater Force to expand themselves than when dispersed, and so both enlarge the Dimensions, and lessen the *specifick* Gravity of Water thus congeal'd into Ice. Hence we may guess at the manner, how Water impregnated with *Salts*, *Earths* or *Sulphurs*, which  
are

are not easily dissolvable, may form itself into *Metals, Minerals, Gems,* and other *Fossils*, the Parts of these Mixtures becoming a Cement to the Particles of Water, or getting into their Pores, change 'em into these different Substances.

*Corollary.*

Hence it is plain, that the Quantity of Water on this our *Globe* does daily decrease, some part thereof being every Day turn'd into *Animal, Vegetable, Mineral,* or *Metallick* Substances, which are not easily dissolv'd into their component Parts again; for separate a few Particles of any Fluid, and fasten them to a solid Body, or keep 'em asunder from one another, and they are no more fluid, to produce which, a considerable number of these Particles are necessarily required.

§ XXIX. *Mercury* seems to consist of exceeding small, smooth, solid, spherical or *spheroidal* Particles; for since *Mercury* in ever so small Quantities is absolutely opaque, and lets none of the Rays of Light pass; and since, whatever be the Cause of Reflexion and Refraction, Light being Material, must either make or find a Passage through every refracting *Medium*; since likewise it is probable, that Light does not penetrate through the solid Substance of the constituent Particles of Fluids, but  
rather

rather through their Pores and the Vacuities form'd by their Orbicular Figures, it's plain therefore, that the Particles of *Mercury* have very few Pores, and if they be *Spherical*, that their Diameters are not much greater than those of the Particles of Light, for these Interstices are as the Cubes of the Diameters of the *Globules*, by whose meeting they are form'd; and seeing Light cannot pass through these Interstices, it is plain, that the Diameters of the Corpuscles of *Mercury* must not be much greater than those of Light; and if these Corpuscles be *Spheriodical*, or *Oval*, their shortest Diameters must not be much greater than the Diameters of the Particles of Light, to form Passages for it. The Solidity of the Particles whereof *Mercury* consists, and the smallness of the Interstices they leave between them, accounts for that wonderful Gravity of *Mercury*, above other Fluids.

§ XXX. *Air* seems to consist of *Spires* contorted into small Spheres, through the Interstices of which, the Particles of *Light* may freely pass, and this is the Reason why it is so light, the solid Substance of the *Spires* being very small in proportion to the Spaces they take up; their being spiral, accounts for the elasticity of *Air*; their being spherical Particles which gives free Passage to any Heterogeneous Matter, accounts for *Air's* being compressible, as also how when compress'd it retains

its fluidity, because spiral Spheres, through which another Matter freely passes, when compress'd, form themselves into *Spheriods*, or Figures most resembling them. This Account of the properties of *Air*, may perhaps please some; but there is another, which to others seems the more genuine; for, if *Air* be suppos'd to consist of small Particles, which endeavour to recede from one another, with a Force *reciprocally proportional* to the Distances betwixt their Centers; all the Appearances of *Air* may thence be accounted for; for upon this *Hypothesis* they will compose an *Elastick Fluid*, whose *Density* is proportional to its *Compression*, as Sir *Isaac Newton* has demonstrated; *Prop. 23. Pag. 270. 2d Edit.* The *Diameters* of the Particles of *Air* seem to be greater than those of *Water*; and the *Diameters* of the Particles of *Water*, greater then those of *Mercury*; and that of the *Light*, by far the least of all, as shall be afterwards shown.

§ XXXI. Other Fluids (besides that of the *Light*, under which Name I comprehend all that which passes under the Name of *Ætherial* or *Subtile Matter*, which I shall examine hereafter) seem to be compounded of these *Primitive Fluids*, viz. *Water*, *Air*, *Mercury* and *Light*; and of Particles of *Salts*, *Earths*, *Sulphurs*, and such like Ingredients, and the Varieties of such mixt Fluids may in the general be thus estimated. 1. Supposing all other things alike,

alike, especially the *Primitive Fluid*, and the Figure of the parts of the Ingredient, the mixt Fluids will differ proportionably to the Magnitude of the parts of the solid Body, which mixes with the Fluid; thus Water or *Lymph* mix'd with *Globules* of Flesh or Blood of a greater *Diameter*, will make a different Liquor from the same *Lymph*, mix'd with *Globules* of Flesh or Blood of a less *Diameter*. 2. *Cæteris Paribus*, (especially the Fluid, the Figure, and the Diameters of the mixing Ingredient being the same,) the Liquor will differ proportionably to the Difference of the Firmness or Softness of the Parts of the mixing Ingredient; thus *Mercury* mix'd with *Globules* of *Diamond*, would make a different Fluid from *Mercury* mix'd with *Globules* of Silver or Brass. 3. All other things being suppos'd the same, the Fluid will differ proportionably to the Difference of the specifick Gravities of the Particles of the mixing Ingredients; thus a mixture of *Gold* and *Mercury* will make a different Liquor from that of *Mercury* and *Lead*, the Difference of the specifick Gravities being here only considered. 4. All other things being suppos'd the same, the Liquor will differ according to the different Degrees of the Cohesion of the solid Parts among themselves; thus, *Mercury* mix'd with little spherical *Magnets*, will make a different mixture from that of *Mercury* mixt with little Spheres of *Lead* or *Iron*. And these seem

to be the *Primogenial* Differences of mixt Fluids; now, not only all these may be differently combin'd with one another, and with the four *Primitive Fluids*, but also the Figures of the solid Parts in the mixture may be infinitely diversified, (whereas we have hitherto only suppos'd all the mixing Solids *spherical*) which will make an infinitely infinite Variety of mixt Liquors.

§ XXXII. That *Light* is a Body, or a material Substance, seems to be evident from these Considerations. 1. It is progressive, and requires a determin'd time to go from one place to another, and is not propagated in an Instant, as is plain from Mr. *Romer's* Reasonings upon the *Eclipses* of the *Satellites* of *Jupiter*, (which are confirm'd by the Observations of other *Astronomers*) whereby he demonstrates, that *Light* requires about ten Minutes to come from the *Sun* to us. 2. It may be stopt or resisted in its Passage from one place to another, by the Interposition of an opaque Body, as other Fluids are stopt in their Courses by the Opposition of any solid Body. 3. It may be congregated within a narrower, or scattered thro' a larger Space, as is evident from reflecting *Specula*, and refracting *Burning-Glasses*. 4. It may be reflected, and the Determination of its Motion changed like other Bodies, and it observes the same Law in its Reflexions that other Bodies do, *viz.* the *Angle* of Reflexion is

is always equal to the *Angle* of Incidence. 5. It may be put out of its Course more or less, according to the Nature of the *Medium* through which it passes. 6. It acts upon the *Organs* of *Animals*, and upon all other Bodies, as other fluid Substances do, by striking upon them with a determin'd Force, by communicating a certain Degree of Motion to them, by separating their component Parts, and putting them in Motion; all these Effects we daily see. 7. It may be confin'd and shut up in determin'd Spaces like other Fluids. The Light of the *Sun* will warm and heat other solid and fluid Bodies, which Effects, continue when their Cause is remov'd; the parts of Light are yearly imprison'd in Fruits, Plants, and other Vegetables, as we see by the Spirits and warm Juices they afford. 8. Lastly, The parts of Light are endow'd with various *Original Colours*, some are *Red*, others *Blue*, others *Yellow*, and some *Green*, as Sir *Isaac Newton* has demonstrated, and may be seen by a *Prism* applied to the Hole of a darken'd Room through which the *Sun* shines. Now all these are the Properties of Bodies, and can belong to nothing but Material Substances.

§ XXXIII. That the Particles of *Light* are extremely little or small, we may conclude from thence, that they pass through almost all Bodies that are pervious, such as *Chrystals*, *Glasses*, *several Gems*, and almost all Fluids but

*Mercury*; and that it freely passes where no other Fluid, how thin soever, can enter, and yet, no Eye, however assisted, has been able to discover or distinguish the parts of the grossest Fluid. But what most of all demonstrates their smallness, is, that Light may be propagated from innumerable different *Luminous Bodies*, without any considerable opposition to one another; suppose a Plate of Mettal (having at the top the smallest Hole can be made) were erected *perpendicularly* upon a *Horizontal Plane*, and about it were set innumerable luminous Objects of about the same height with the Plate, at an ordinary Distance from it, the Light proceeding from every one of those Objects, will be propagated through this small Hole, without interfering. This will appear by applying a dark Object in a straight Line against the Luminous Body, for the Light of this Body will through the Hole be receiv'd upon the dark Body: Now it is impossible that so many different *Streams of Light* cou'd be transmitted through so small a Hole, were not the Particles of Light extremely small. Add to this, that were not the Particles of Light extremely little, being extremely swift, (*i. e.* more than a Million of times swifter than a *Cannon Bullet*, continuing in its greatest Velocity, as shall be presently shown) they wou'd peirce all kinds of solid Bodies with almost as great Facility as they do Vacuities, whereas we see Light regularly

gularly reflected from some Bodies. Moreover, we find that innumerable different Spheres of Light within our *Horizon*, may be propagated from their several luminous Centers, without interfering. How many Millions of Candles and *Flambeaux* may we see sending out their *Tides* of Light, without clashing upon one another, which argues both the Smallness of the Parts of Light, and the Largeness of the void Interstices between the Particles of Air and other Bodies.

§ XXXIV. How extremely swift the Particles of *Light* are, we may gather from the forementioned Experiment of Mr. *Romer's*, whereby he demonstrates, that the *Streams* of *Light* pass from the *Sun* to our *Earth* in about ten Minutes; and *Hugens* in his *Cosmotheoros*, has prov'd, that a *Bullet* continuing in the Velocity with which it leaves the *Mulle* of the *Cannon*, wou'd require twenty five Years to pass from us to the *Sun*: Now the *Via Percursa* being the same in both, the Velocities will be reciprocally as the times, *i. e.* the Velocity of *Light* will be to that of a *Cannon-Bullet*, persisting in its greatest swiftness, as twenty five Years is to ten Minutes; or as 1314700 to one *Proxime*, so that the Velocity, with which the Particles of *Light* pass, will be more than a Million of times swifter than a *Cannon-Bullet*. Moreover, the Distance betwixt the *Sun* and *us*, is at least 12000 *Dia-*

*meters* of the Earth, but allowing it to be only 10000 *Diameters*, the Light runs a thousand *Diameters* in a Minute, or sixteen and half *Diameters* of the Earth in a Second, or beating of an Artery, that is more than 1100000 *Toises*, since the *Diameter* of the Earth contains 2865 *French Leagues*; and every *League* contains 2282 *Toises*, according to the Numbers of Mr. *Picard*. But Sound goes but about 180 *Toises* in a Second, wherefore Light is about six hundred thousand times more Swift than Sound. Likewise, since the Earth's middle *Diameter* is 7846 Miles, each of which contains 5000 Feet; and since Light goes in a Second or in a pulse of an Artery, sixteen and a half *Diameters* of the Earth, it is plain, that in every Second it runs at least a hundred and thirty thousand Miles, which is a prodigious and almost an incredible Space in so short a time. But the extraordinary Effects of Light and Heat, seem to require all this; we see how powerfully it acts (being congregated) upon the most compact solid Bodies, and we never perceive any diminution of its Force arising from an abatement of its Velocity.

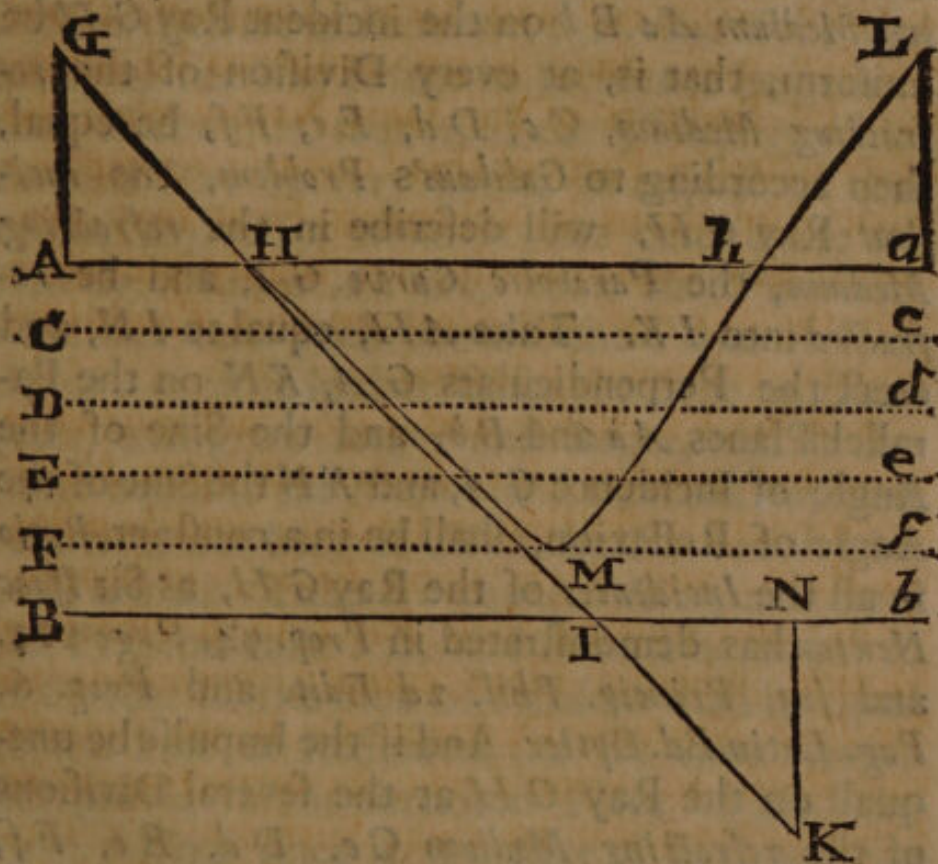
§ XXXV. The *Sun* and fixt *Stars* seem to be huge, dense Bodies (like the *Earth* or *Planets*) heated to an extraordinary Degree, and their Heat probably may be preserv'd by the greatness of their Bodies, and the mutual Action and Re-action between their Parts, and the  
Light

Light which they emit; and their Parts are kept from fumeing away by their *fixity*, and also by vast Weight and Density of the *Atmospheres* incumbent upon them, and powerfully compressing them, and condensing the Vapours and Exhalations which arise from them. The best *Image* we can frame to our selves of the *Sun*, is to conceive the Body of the *Sun*, and the *Fluid of Light* separated and apart, (and it is highly probable they may be actually separated, and the first intirely drain'd of the latter) the *Sun* then will be like a great *Earth*, only more Dense, Compact, and Solid. The *Fluid of Light*, like that of *Water* or *Air*, but infinitely more subtile, active, and of finer Parts; and that (in compounding them again) the first has been saturated with, or quite swallow'd up in the latter, by which the Parts of the first has been put in strong, quick and vehement Vibrations. When the *Sun* and *fixt Stars* are thus dissolv'd and drench'd in this Fluid, the Light will be emitted from them by the vibrating Motion of their Parts, after the manner we see Iron, when heated to such a Degree, as to be just going into Fusion, by the vibrating Motion of its Parts, send forth with Force and Violence, copious Streams of liquid Fire all around: great Bodies preserve their Heat longest, and that perhaps in proportion to their *Diameters*. Sir *Isaac Newton* has made it probable, that the *Comet* which appear'd in 1680, by approach-

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the Rays have to the Plane of *Incidence*, the Sine of the *Angle of Incidence* of every Ray considered apart, shall have to the Sine of the *Angle of Refraction* a constant *ratio*: In the following *Scheme*, let the similar *Mediums* be distinguish'd by the two Parallel Lines *Aa* and *Bb*, which are suppos'd to define a *Medium* different from the other two. Let this *Medium* be



divided by parallel pointed Lines *Cc*, *Dd*, *Ee*, *Ff*, into similar Planes. Let *GH* be the *incident Ray*. And suppose the *refracting Medium* *Aa*, *Bb*, begins to act upon it, either when it enters into it at *H*, or at some certain *Distance* from it on the one side, and ends at a certain  
Distance

Distance from it on the other; and that at all Places between these two Limits, the *refracting* Plane acts upon the Ray in Lines whose Direction is *perpendicular* to that Plane; and that the Actions upon the Ray at equal Distances from the refracting Plane, be equal; and at unequal ones, either equal or unequal, at any Rate whatever. If the Impulse of the *refracting Medium*  $Aa Bb$  on the incident Ray  $GH$  be uniform, that is, at every Division of the *refracting Medium*,  $Cc, Dd, Ee, Ff$ , be equal, then according to *Galileus's Problem*, the *incident* Ray  $GH$ , will describe in the *refracting Medium*, the *Parabolic Curve*  $GI$ , and be *refracted* into  $IK$ . Take  $AH$ , equal to  $IN$ , and erect the Perpendiculars  $GA, KN$  on the Parallel Planes  $Aa$  and  $Bb$ , and the Sine of the Angle of Incidence  $GA$ , and  $KN$  the Sine of the Angle of Reflexion, shall be in a constant Ratio in all the *Incidences* of the Ray  $GH$ , as Sir *Isaac Newton* has demonstrated in *Prop. 94. Page 203. and seq. Princip. Phil. 2d Edit. and Prop. 6. Pag. Latin Ed. Optic.* And if the Impulse be unequal on the Ray  $GH$  at the several Divisions of the *refracting Medium*  $Cc, Dd, Ee, Ff$ , yet since it must be uniform through every single Division, if these be suppos'd infinitely little and many, the Proposition will still hold true, whatever be the Law of the Attraction of the Ray, provided its Direction be Perpendicular to the Plane of the *refracting Medium* and

and equal, at equal Distances from it. And since by the 2d Corollary of the 3d Law of Nature, the oblique Force of the incident Ray  $GH$ , may be divided into the two Forces  $GA$  and  $AH$ , and of the refracted Ray  $IK$ , into  $KN$  and  $IN$ ; it is evident, that the Velocity of the Ray before its Incidence, is to its Velocity after it Emerges; as the Sine of Emergence  $KN$ , to the Sine of Incidence,  $GA$ . And if the Velocity of the Ray before its Incidence be greater than afterwards, that is, if the Obliquity of the Incident Ray be very Great, in respect of that of the Refraction when it has enter'd the Refracting Medium  $AaBb$ , then the Parabolick Line will turn back toward the Plane of Incidence; because in that Case, the Sine of Emergence will grow larger and larger, till it become equal to the Radius, and then the Ray must return somewhere at  $M$  in the Parabolick Line  $AHmhl$ . Take  $ha$  equal to  $HA$ , and erect the Perpendicular  $aL$ , and it shall be equal to  $AG$ , that is, the Sine of Incidence shall be equal to the Sine of Reflexion, as Sir Isaac Newton has prov'd in the forecited Place of his Principle. Now since it is matter of Fact and Experiment, that the Sines of the Angles of Incidence, and Refraction in all Rays of whatever Nature, observe a constant ratio, and that the Angles of Reflexion and Incidence are equal; it is therefore on the other hand true, that the Rays of Light are thus urg'd by the Refracting Media,

*Media*, and their Velocity thus abated by *reflecting* ones, so that it is evident, *Refraction* and *Reflection* proceed from one and the same Principle, acting differently in different Circumstances, that is, when the Obliquity of the *Incident Ray* is great, and the *Refractive Power* of the *Medium* is also considerable, the Ray will be reflected: But if its Angle of *Incidence* be large, and the *Refractive Power* of the *Medium*, not very strong to throw it far from the Perpendicular, it will be *Refracted*.

¶ XXXVII. Sir *Isaac Newton* has demonstrated from plain and convincing Experiments, that the *Light* of the *Sun* consists of Rays differently *refrangible* and *reflexible*, and that those Rays are differently *reflexible*, that are differently *refrangible*. These Rays that are all alike *refrangible*, he calls the *Light* of them Simple and *Homogeneous*, and those that are some more *refrangible* than others, he calls their *Light*, Compound and *Heterogeneous*; the greater or less *Refrangibility* of Rays, is their Disposition to be turn'd more or less out of their way, in like Incidences on the same *Medium*; and their greater or less *Reflexibility* is their Disposition to be return'd back more or less easily into the same *Medium* from any other, upon whose Surface they fall. *Refraction* out of the Rarer *Medium* into the Denser is made so, that the *Angle* of *Refraction* is less than the *Angle* of *Incidence*, and on the contrary. The Colours of

*Homo-*

*Homogeneous Light* are these, *Violet, Indico, Blue, Green, Tellow, Orange and Red.* These Colours in the Objects are their Disposition to reflect this or that sort of Rays more copiously than the rest; and in the Rays of *Light* they are their Disposition to propagate this or that Motion into the *Organs* of Vision, and in *them*, they are Sensations of those Motions under the Forms of Colours; the Rays that produce Red Colours, are least *refrangible*, and those that make Violet, the most, and the rest are more or less *refrangible*, as they approach either of these Extremes in the Order set down, that is, Orange is least *refrangible*, next to Red, and Yellow next to Orange, and so on. All the Colours of the Universe which are made by Light, are either the Colours of *Homogeneous Lights*, or compounded of a Mixture of those: Whiteness is produc'd by a due Mixture of all the *Primary Colours* of *Homogeneous Light*; and Blackness by a Suffocation, or *Non-reflexibility* of Light; and all Grey Colours, betwixt Black and White, may be compounded of all the *Primary Colours* mixt in a due Proportion; the *Primary Colours* of *Homogeneous Light* are unchangeable in their Nature, and no *Reflexions* nor *Refractions* will change any of these into another: whereas by the due Mixture of colour'd Bodies, Colours may be produc'd by Composition, which shall be like to the Colours of *Homogeneous Light*, but not as to the

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immutability of Colour ; for that may be chang'd according to the Colour of the Light by which they are seen ; so that if the *Sun's* Light consisted but of one sort of Rays, there wou'd be but one Colour in the whole World, and it wou'd be impossible to produce any new Colour by *Reflexions* or *Refractions*, for all the Variety of Colours depends upon the different Composition of Light.

§ XXXVIII. The Rays of Light which fall upon Bodies, and are *reflected* or *refracted*, begin to bend before they arrive at the Bodies. Sir *Isaac Newton* has shown by several Experiments of Rays passing by the Edges of Bodies, that they are *incurvated* by the Action of these Bodies as they pass by them, and that this Action is strongest at the least Distance ; he has demonstrated likewise, that the Cause of *Reflexion* is not the impinging of Light on the solid and impervious Parts of Bodies. For (not to repeat those other Arguments which he has brought in great plenty) since Glass can be no other ways polish'd, than by grating and scratching it by Substances, whose Parts are small and subtile, so that the Scratches and Frettings of its Surface become too small to be visible, yet not so small as to become truly plain or *spherical*, and all together to compose one Surface ; if Light were *reflected* by impinging upon the solid Parts of Glass, it wou'd be scatter'd as much by the most polish'd Glass, as by the roughest,

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since all Action is mutual, Sulphurs act most upon Light: and that the Action between Light and Bodies is mutual, is evident from this Consideration, that the densest Bodies which *refract* and *reflect* Light most strongly, grow hottest in the Summer Heat, by the Action of the *refracted* and *reflected* Light. The Bodies that reflect Light, are those whose Pores are fill'd with *Mediums* of an unequal Density with that of the *refracting Medium* it self, and Bodies become more transparent, by filling their Pores with Fluids of equal, or almost equal Densities with their Parts, as Paper dip'd in Water or Oyl: and on the contrary, the most transparent Substances may, by evacuating their Pores, or separating their Parts, be render'd sufficiently opaque, as Salts or wet Paper dry'd, Glass by being pulveriz'd, or Horn by being scrap'd.

§ XL. The *least Parts* of almost all Natural Bodies are transparent, as may be seen by viewing small Bodies with a *Microscope*, and consequently, they must, according to their several Sizes, reflect Rays of one Colour, and transmit those of another, upon the same Ground that thin Plates reflect or transmit those Rays; for a thin Plate of an even thickness appears all over of the same Colour, and if this Plate were slit into *Threads*, or broken into *Fragments* of the same thickness with the Plate, there is no reason why every *Thread* or *Frag-*

*ment* should not keep its Colour, and consequently, why a heap of those *Threads* or *Fragments* should not constitute a Mass or Powder of the same Colour which the Plate exhibited before it was broken; and the small Parts of all Natural Bodies being like so many *Fragments* of a Plate, must on the same Grounds exhibit their Colours. Now Sir *Isaac Newton* found by Observation, that thin Plates or Bubbles *reflected* Rays of one Colour and *transmitted* those of another, according to their several thickness or thinness; and therefore the small Parts of Natural Bodies being transparent, must upon the same Grounds *reflect* or *transmit* the several sorts of Rays: and this is the Foundation of the various Colours of all Natural Bodies. But the parts of Bodies on which their Colours depend, must be denser than the *Medium*, which pervades their Interstices; and as there is a constant Relation between Colours and *Refrangibility*, the most *Refrangible* Rays being *Violet*, the least *Refrangible* *Red*, and those of intermediate Colours having proportionally intermediate Degrees of *Refrangibility*; so there is a constant Relation between Colour and *Reflexibility*, the *Violet* being in like Circumstances reflected at least thicknesses of any Plate or Bubble, the *Red* at greatest thicknesses, and the intermediate Colours at intermediate thicknesses; and there are several Orders of those Colours more or less intense and vivid, according

to the several thicknesses of these Plates or Bubbles: and the reason why the Surfaces of all thick and transparent Bodies reflect part of the Light incident on them, and refract or transmit the rest, is, that some Rays at their *Incidence* are in *Fits* of easie *Reflection*, and others in *Fits* of easie *Transmission*. Those who desire full Satisfaction in this wonderful Appearance of Nature, must go to that late admirable Treatise of *Opticks*, written by Sir *Isaac Newton*; for it is impossible to separate the Parts of this Work from one another without Disadvantage to them, or to sum them up in a less room, without losing something *New* and *Useful*. That great Person having before shown how far *Numbers* and *Geometry* would go in *Natural Philosophy*, has now manifested to the World to what surprizing Heights, even vulgar *Experiments* duly managed and carefully examined in such Hands may advance it. In the general, I think we may safely conclude from Sir *Isaac Newton's* Discoveries. 1. That the *Sun* and *sixt Stars* are but *Planets* or *Earths* vehemently heated; or having their smallest Parts put in a strong *vibrating* Motion. 2. That Light is emitted from them, by these powerful *Vibrations* of their smallest Parts. 3. That this Fluid of Light emitted from these *vibrating* luminous Bodies, requires a certain time in passing from them to us, and moves after the same manner other Fluids do, only with a much greater

ter Velocity. 4. That Bodies draw this Light to 'em in Lines *perpendicular* to their Surfaces, and that this Light puts the parts of these Bodies in a *vibrating* Motion wherein Heats consist. 5. That the Motion of Light is swifter in Bodies than *in vacuo*, by reason of this Attraction; and slower after its being *reflected*, than in its *Incidence*, because that Force of Attraction which accelerates its Motion in its *Incidence*, must of necessity retard its Motion in its *Reflexion*, by reason of the different Direction thereof. 6. That the Ray in its whole Course of *Reflexion* and *Incidence* describes a *Curve*, or is rather bended than broken. 7. That the *Vibration* of the smaller parts of Bodies produc'd by the Action of Light, when brought to a certain Degree of Strength, is the Cause of their Light; just as we see the *Vibrations* produc'd in the Air by tremulous and sonorous Bodies, must be of such a determin'd Force to produce a distinct Sound. 8. That these *Vibrations* produc'd in Bodies by the Action of Light, when their Motion conspires with that of the Rays of Light, *i. e.* when any Ray is in that part of these *Vibrations* that has the same Direction with that of the Ray, it easily breaks through a *refracting* Substance, but when it is in the contrary part of the *Vibration*, which impedes its Motion, it is easily reflected, and so every Ray is dispos'd *alternately* to be easily *reflected* or easily *transmitted*. 9. That the  
Rays

Rays of Light are of their own Nature diversly *Refrangible* and *Reflexible*, and that this diversity in both arises from the same Principle, acting differently in different Circumstances, *viz.* the Action of Bodies upon Light. 10. That *Reflexion* is caus'd by the different Densities of Bodies, and happens only in *Superficies* that intercede *Mediums* of different Densities. 11. That Light is totally transmitted through *Mediums* only that are of the same uniform Density, and that the *refractive* Power of Bodies is principally owing to the Sulphurs with which they abound; for since all Action is mutual, and since Light congregated by a Burning-Glass acts most upon Sulphurs, so Sulphurs ought to act most upon Light. 12. That the Forces of Bodies to *reflect* or *refract* Light are very nearly proportional to the Densities of the same Bodies. 13. That certain Colours are ty'd to such Degrees of *Refrangibility* or *Reflexibility*, and that all the *primitive* and *original* Colours depend upon these Degrees. 14. That *White* consists in an equal mixture of all the *primitive* Colours, and *Black* in a Suffocation of all the Rays of Light, which is the reason why *Blacks* burn more easily than other Colours; and other not *primitive* Colours arise from a certain mixture of these. 15. That the Colours of Natural Bodies depend upon the different Density of their small Parts, and thereby their fitness to reflect Light of one

Colour and transmit that of others. 16. That several sorts of Rays make *Vibrations* of several bignesses, which according to their bignesses excite Sensations of several Colours much after the same manner, that the *Vibrations* of the Air according to their several bignesses excite Sensations of several Sounds. 17. That the *Harmony* and *Discord* of Colours arise from the Proportions of the *Vibration* propagated thro' the Fibres of the Optick Nerves into the Brain, as the *Harmony* and *Discord* of Sounds arises from the Proportions of the *Vibrations* of the Air.

*Corollary.*

From what has been said of the Nature of the *Sun*, and its *Light*, it is evident, that the Quantity of Heat and Light in the *Sun* doth daily decrease; like other vehemently hot Bodies it must gradually cool; as also, by its *Emission* of so many Millions of Rays perpetually, quite round its Body, upon all the *Planets* within its System, which do not return, both its Bulk and Heat must be diminished. It is not improbable that all the virtual Heat in the Juices of Vegetables, Metals and Minerals, may be owing to the Action of the imprisoned Rays in 'em: the Production of Animals in the ordinary way, requires a certain Degree of Warmth, which proceeds from the *Sun's* Influence. Some Bodies do stifle and suffo-

suffocate the Rays of Light, so as that they are never, or not duly reflected again. Sulphurous and Bituminous Bodies form little Cells by the Action of the Rays of Heat and Light, to retain 'em. All Bodies burn and emit Flames in proportion to the quantity of *Sulphurs* in 'em. Spirits by frequent Distillations may be drawn out of *Vegetable* Juices which shall flame and fume away of themselves in the open Air. Nay, the *Sulphurous* parts of some Bodies may be so separated from their Salin and Earthy parts, and so united, as to continue their Flames and Burnings even when cover'd over with Water; as the liquid and solid *Phosphorus*, which only show their Flames more conspicuously when expos'd to the Air: all which show how readily Light and Fire of all kinds, *Solar* and *Terrestrial*, are receiv'd by *Sulphurs*, and how closely they are united with them; so that the Rays of the *Sun* are certainly swallow'd up by *Sulphurous* Bodies, and cannot be returned to their Fountain-head. Some have thought that the Rays and Light of the *Sun* were disseminated through the whole Body of the *Atmosphere*, even when their Fountain was got quite below our *Horizon*, by observing, that *Mercury* shut up in a *Tube* exhausted of Air, if the *Mercury* had been first well cleans'd, the *Tube* perfectly exhausted and closely seal'd up, but not quite fill'd with the *Mercury*, upon shaking briskly and frequently the *Tube* under these Circumstances, in a darken'd Room, copious Gleam

Gleams of Light would thereby be emitted, so as to enlighten the whole Room. But Mr. *Hauksbee* has made it evident, that any Friction with the Hand, or other soft Body, on an exhausted Glass, *Sphere* or *Cylinder*, when violently agitated or turned round very quickly, even without the *Mercury*, will produce the same Appearance; whereby it is evident, that it is the *Friction* which produces the Effect in both Cases; the *Mercury* in the Agitations of the *Tube*, rasping the Sides thereof, and setting its Parts in proper *Vibrations*, and the Hand or other soft Body, closely apply'd to the whirling exhausted hollow *Sphere*, or Glass *Cylinder*, producing the same effect; the drawing out the Air in both Cases contributing nothing to the Effect, but as the removing an Impediment to the due *Vibration* of the parts of the Glass; as we see the Application of any Foreign Body close to a Sonorous Body, will hinder those *Vibrations* which are the Cause of its proper Sound; and it is the proper, quick and strong *Vibration* of their Parts, that is the Cause of Light in Glass Bodies, and all others susceptible of it. But since it's certain, that Bodies do attract the Rays of *Light*, and do retain 'em so, that they can never return to the Fountain of *Light* again; it's plain, the Quantity of *Light*, both in this *Bright Luminary*, and in the *Sun-like fix'd Stars* must be continually decreasing. There is no Reason can be assign-

ed for doubting, that the *fix'd Stars* are of the same precise Nature with our *Sun*, and there are several probable Reasons can be assign'd to show their Similarity; the Light in both is of the same Nature, and all the several *Systems* transmit their Light into one another: Now it is Fact, that several *fix'd Stars* have disappeared for many Years, some having again appeared, others never, as is evident from the Observations of *Astronomers*. And it's not unlikely that these disappearing *fix'd Stars* were actually extinguish'd, that their Heat and Light were actually spent and exhausted, and they turned into mere opake and gross *Planet-like* Bodies, and would for ever continue so, if not re-kindled, and new recruited with Heat and Light; the Possibility of which, in some of the extinct *fix'd Stars*, may be afterwards accounted for. And if this be not very far from the Truth, we have here an undeniable Proof of the Possibility of the Decrease of Heat and Light in the *Sun*. However, it's also certain, that this Decrease is very inconsiderable in any short time; tho' we are sure there is some, and our not being sensible of this Decrease, is only an Argument of the exceeding Smalness of the Particles of *Light*. We find some *odoriferous* Bodies send out Steams for many Years, without sensibly diminishing either in their Bulk or Weight, which argues the Smalness of the Parts of these Steams. But the Particles of *Light*  
must

must be extremely small, since the *Sun* for so many Ages has been constantly emitting *Oceans* of Rays, without any sensible Diminution: But this can surprize no Body who considers that Matter is infinitely divisible; for it is possible to assign in Numbers, a Quantity, whereof a Body as big as the *Sun* may constantly, for any finite Number of Years emit *Oceans*, and yet the Sum of 'em all may not be greater than a cubical Inch, or even a Grain of Sand.

§ XLI. We have already observ'd, that the most general Condition of the *Universal Law* of Gravitation in Bodies, was, that at the same Distance from the Center of the attracting Force, Bodies did gravitate in proportion to their Solidity, and at different Distances, *reciprocally* as the Squares of those Distances; but this Condition may not be so general, as altogether to exclude others: The way to know how this *Universal Law* is diversify'd, in the different Bodies, is to observe what Lines Bodies in their Motions or Actions upon one another describe, or what the Effects of these Motions and Actions are; and then to investigate what Conditions of the *Universal Law* of Gravitation will make Bodies describe these Lines, or produce these Effects. Thus if any of the *Primary* or *Secondary Planets* did describe perfect Circles or *Ellipses* about the *Sun*, or a *Primary Planet* plac'd in the Center, the Condition of the *Universal Law* in these would be,  
that

that the *attractive Force* at different Distances from the Center, would be as these Distances directly. If they described a *Parabola*, by supposing the *attractive Force* at an infinite Distance, or an *Hyperbola*, by changing the *Centripetal* into a *Centrifugal Force*; then the Condition of the *Universal Law* would be, that the Force were always *equable* and the same at all Distances in the first Case, and as the Distances *directly* in the second, as Sir *Isaac Newton* has demonstrated, *Prop. 11. Lib. I.* We find, as has been insinuated in the preceding Sections, That the Rays of *Light* in passing thro' different *Media*, are attracted *perpendicularly*, to either the Plane of *Incidence* or *Reflexion*; so that the Force of Attraction is always the same, at equal Distances from the same Plane. We see that the Parts of *Air* shun or fly from one another, instead of tending to one another; so that in accounting for the Appearances of Nature from the *Universal Law* of Gravitation, we are not ty'd to one single Condition, but may have recourse to others, as the Nature and Necessity of the Appearances seem to require; for the whole Difficulty of *Philosophy* seems to lie in investigating the Powers and Forces of Nature, from the Appearances of the Motions given, and then from these Powers to account for all the rest.

§ XLII. The obvious Appearances of *cohering* Bodies are thus: Two very smooth, well-polished

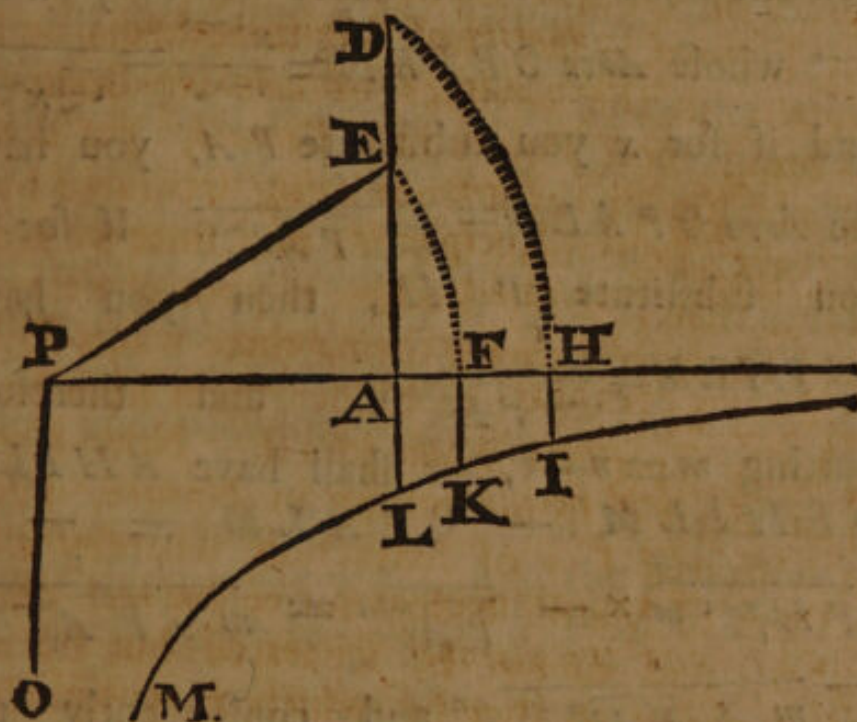
polished plain Bodies, put together, will firmly cohere, even in an exhausted Receiver; which shows evidently that their *Cohesion* is owing, neither to the Gravity, nor to any other Property of the Air; Saline Particles, when at a proper distance, and at freedom, will shoot and unite into Clusters of themselves: All saline, crystalline, and most mineral Bodies, break in very smooth and plain, or at least *congruent* Surfaces; and universally almost all hard and very compact Bodies, break with Surfaces, which immediately upon the Separation, appear whitish, which is an Evidence, that tho' the Surfaces be very small, yet they are very smooth and polish'd, for only innumerable little polish'd Surfaces are fit to reflect plentifully all kinds of Rays, whereby white Colours are produc'd. Now these Appearances of *cohering* Bodies, do naturally lead us to imagine, that one necessary Condition toward *Cohesion*, is the plainness, or at least *Congruity* of *cohering* Surfaces, and this seems necessary to exclude any Fluid from lying between *cohering* Bodies; for these Bodies cannot be said to *cohere*, or be continued, betwixt whose *cohering* Surfaces, in all their Points a Fluid may insinuate it self. The plainness and smoothness of the *cohering* Surfaces, will make more Points come into *Contact*, than when they are rough and irregular. For whatever Cause *Cohesion* arises from, if we suppose that Cause

to act most strongly at the *Contact*, the more Points of the *cohering* Bodies come into *Contact*, the firmer the *Cohesion* will be; and tho' exact Congruity in *Curve* Surfaces, will bring as many Points into *Contact* as plain Surfaces will, yet *Curvity* not being the simplest, nor most expeditious Method of producing this Effect, neither agreeable to Nature (who always brings about all her Effects the shortest and easiest way) it seems evident, that the plainness and smoothness of Surfaces, is one Condition of *Cohesion*, and that those *Atoms* that are terminated with plain Surfaces, will (*ceteris paribus*) produce Bodies of the firmest *Cohesion*. This will appear more evident from the contrary Quality in the constituent Particles of Fluids: For we have shown before, that one necessary Condition of *Fluidity*, is the *Curvity* of the Surfaces of the constituent Particles of Fluids, whereby their *Cohesion* is very small, in respect of the *Cohesion* of those Particles that are terminated with plain Surfaces, and their Gravity always exceeds the Force of their *Cohesion*, so that from both these Causes, they easily slip and move one upon another. We may then suppose, that some of the *Primary Atoms* of which Bodies are constituted, are terminated with plain Surfaces on all sides, which will produce Bodies of the firmest *Cohesion*; others are partly terminated with plain, and partly with *curve* Surfaces, which will  
pro-

produce Bodies of a mean *Cohesion*; others again are intirely terminated with *curve* Surfaces, which will produce Fluids, and between those intirely plain, and intirely *curve*, there are infinite *Combinations* of plain and *curve* Surfaces, which will account for all the various Degrees of *Cohesion* in Bodies, in respect of their Figures. But tho' this smoothness and plainness in the Surfaces of *cohering* Bodies, will bring most Points into *Contact*, yet this will not hinder them from being separated by any Force, how small soever; and since we are certain, that *cohering* Bodies require a determined Force to separate them, there wants still a *Cement*, as it were, to hinder them from being easily separated when join'd. Now this can be deriv'd from nothing in Nature, but that *Universal Law* of Attraction, whereby all the Parts of Matter endeavour to *embrace* one another, and cannot be separated but by a Force superior to that by which they attract one another; let us then enquire what Condition of the *Universal Law* will most fitly answer the Appearances of *Cohesion*.

§ XLIII. On the Center *A*, and at the Distance *AD*, let a Circle be describ'd, to whose Plane at *A*, let *PA* be perpendicular, and *P* be a *Particle* of Matter, attracted by all the Particles of this Circle, in any Condition of the *Universal Law*, from *P*, to any Point in the  
the

the *Radius* of the Circle draw  $PE$ , in the right Line  $PA$ , take  $PF = PE$ , and at  $F$  draw  $FK$  parallel to  $AD$ , of such a length as may represent the Force whereby the Particle  $E$  at-



tracts the Body  $P$ , and let  $LKI$  be the *Curve* which the Point  $K$  thus constantly circumstantiated Generates: Sir *Isaac Newton* has demonstrated, *Pag.* 196. *Prop.* 90. *Lib.* I. *Princip.* *Phil. Mathemat.* 2d *Edit.* that the Force whereby the whole Circle, upon the *Radius AD*, attracts

tracts the Corpuscle  $P$ , is as the  $AHIL$  multiplied upon the Distance  $AP$ , let  $PF$  be called  $x$ , and  $FK$ ,  $y$ ; and let  $FK$ , or the Force whereby the Point  $E$  attracts the Body  $P$ , be reciprocally as any Power (suppose  $n$ ) of  $PF$ ,

then the Equation of the Curve will be  $y = x^{-n}$  whose Area  $OPFKM = \frac{x^{1-n}}{1-n} = \frac{1}{1-n} x^{-n+1}$

And if for  $x$  you substitute  $PA$ , you have the Area  $OPALM = \frac{1}{1-n} PA^{-n+1}$ . If for  $x$  you substitute  $PH$ , then you have

$OPHILM = \frac{1}{1-n} PH^{-n+1}$ , and therefore

putting  $m = n - 1$ , we shall have  $AHIL = OPHILM - OPALM = -\frac{1}{m}$

$\times PH^{-n+1} \frac{1}{m} \times -\frac{1}{PA^{-n+1}} = \frac{1}{m \times PA^{-n+1}}$

$-\frac{1}{m \times PH^{-n+1}}$ , and consequently the Attraction of the Circle upon the Cor-

puscle  $= PA \times AHIL = \frac{PA}{m \times PA^{-n+1}}$

$$\frac{PA}{m \times PA^{-n+1}} = \frac{1}{m \times PA^{-n+2}}$$

$$\frac{PA}{m \times PH^{-n+1}}$$

If

If  $n = 1$ . and  $PA = 0$ , then the *Radius* of the attracting Circle being produc'd, will coincide with the *Asymptote*  $PO$ , in which Case (the *Curve* being the vulgar *Hyperbola*, the *Area*  $AHIL$  will be infinite, and  $PA$  being nothing, or the *Distance* between the *Corpuscle* and the *attracting Plane* vanishing, the *Attraction*  $PA \times AHIL = 0 \times \infty = 1$ .

If  $n = 1$  and  $PA = \infty$  *i. e.* when the *attracting Plane*  $AD$ , is plac'd at the *Concourse* of the *Hyperbola*, with its *Asymptote*  $PH$ , then the Arch  $DH$  (whose *Center* is  $P$ , and whose *Radius* is  $PD = PA = \infty$ .) will coincide with  $AD$ , and consequently  $AL$  and  $HI$  will coincide, and therefore  $PA \times AHIL = \infty \times 0 = 1$ .

If  $n = 1$  and  $PA = a$ , let  $AH$  be called  $y$ , then  $PH = x = a + y$ . And the *Attraction* of the Circle upon the *Corpuscle*  $PA \times AHIL = y - \frac{y^2}{2a} + \frac{y^3}{3a^2} - \frac{y^4}{4a^3} \&c.$

If  $n = 2$ . and  $PA = 0$ , then the *Area*  $AHIL$  will be *more than Infinite* (the meaning of which Expression shall be afterwards explain'd) and therefore the *Attraction* will be  $PA \times AHIL = 0$  multiply'd into more than Infinite; from whence it appears that the *Force* of the *Attraction* in this Case, when  $PA = 0$ , is greater than that in the former Case, where  $n = 1$ . and  $PA = 0$ .

If  $n = 2$  and  $PA = \infty$ , there the *Area*  $AHIL$  will be nothing, and consequently the *Attraction*  $= PA \times AHIL = \infty \times 0 = 1$ . And hence it appears that in this Case, if  $PA = 0$ , the *Attraction* will be greater than when  $PA = \infty$ . for of two Products, having the same Multiplier, that is the greater, which has the greater Multiplicand, so that if  $A$  denote the *Attraction*, when  $PA = 0$  and  $a$  the *Attraction*, when  $PA = \infty$ , I say that  $A$  is to  $a$ , as a greater than infinite is to infinite, contrary to what happen'd in the first Case, where  $n = 1$ , for the *Attraction* in that Case was the same both when  $PA$  was equal to  $0$  and to  $\infty$ , *viz.* 1.

If  $n = 2$  and  $PA = a$ , then as formerly  $AH$  being call'd  $y$ , the *Attraction*  $= PA \times AHIL = \frac{y}{a} - \frac{y^2}{a^2} + \frac{y^3}{a^3} - \frac{y^4}{a^4} + \frac{y^5}{a^5}$ , &c.

If  $m = 3$  and  $PA = 0$ , then  $AHIL$  will be more than infinite, but  $AHIL$  in this third Case will be greater than  $AHIL$  in the second Case, and consequently the Force of the *Attraction* when  $PA = 0$  in both Cases, will be greater in this Case than in the second Case, for the reason now mentioned, *viz.* because  $PA = 0$  is a common Multiplier in both, and  $AHIL$  in this Case is greater than  $AHIL$  in the second.

If  $m = 3$  and  $PA = \infty$ , then as before,  $AHIL$  will be equal to nothing, and consequently the *Attraction* will be  $\infty \times 0 = 1$ .

If

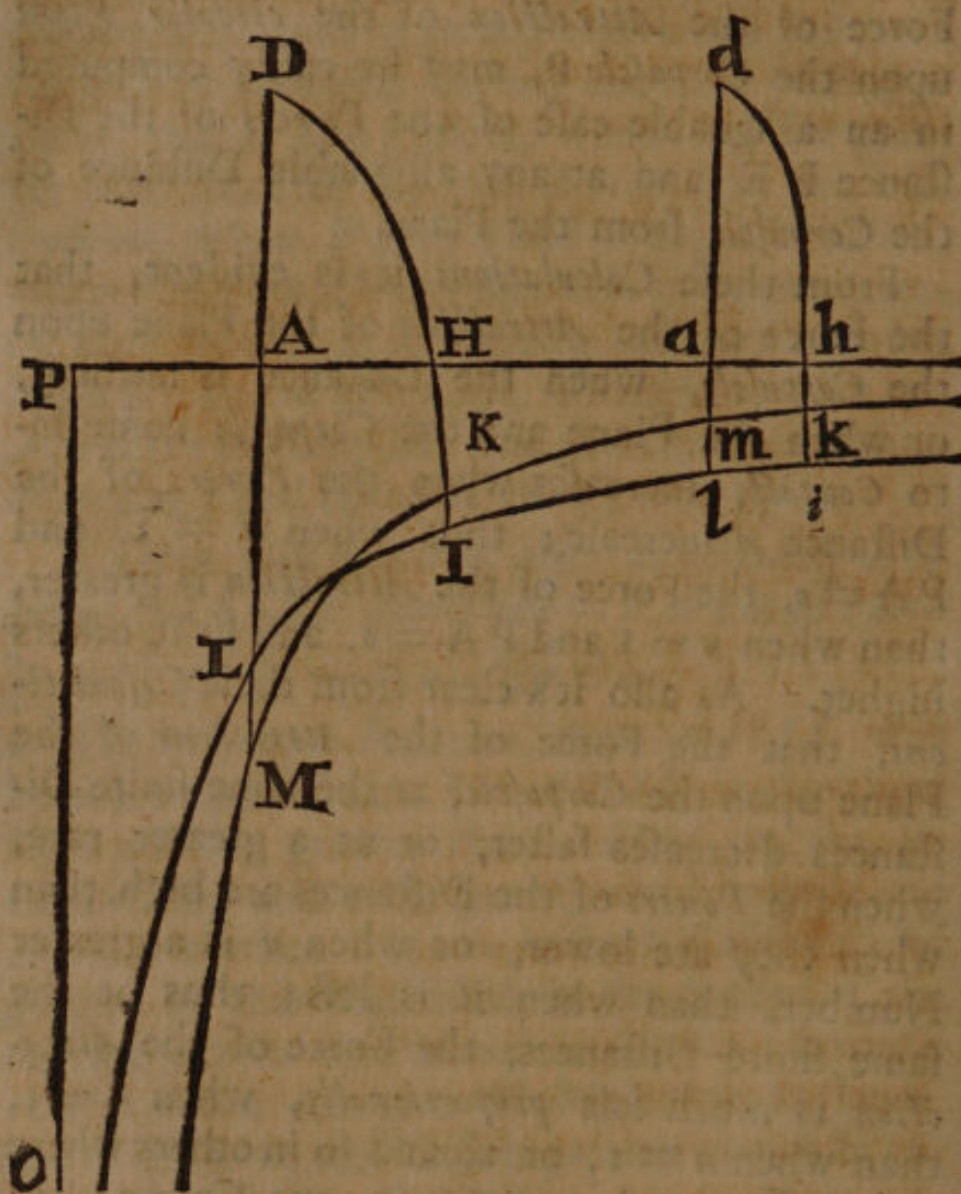
If  $m = 3$  and  $PA = a$ , then the *Attraction* will be equal to  $\frac{y}{aa} - \frac{3y^3}{2a^3} + \frac{2y^5}{a^5} - \frac{5y^7}{2a^7} + \frac{3y^9}{a^9} - \frac{21y^{11}}{6a^{11}}$ , &c. After this manner, the Force of the *Attraction* of the *circular Plane* upon the *Corpuscle P*, may be easily computed in an assignable case of the *Powers* of the Distance  $PE$ , and at any assignable Distance of the *Corpuscle* from the Plane.

From these *Calculations* it is evident, that the Force of the *Attraction* of the Plane upon the *Corpuscle*, when the Distance is nothing, or when the Plane and the *Corpuscle* come into *Contact*, increases when the *Powers* of the Distance  $n$  increase; thus when  $n = 2$ , and  $PA = 0$ , the Force of the *Attraction* is greater, than when  $n = 1$  and  $PA = 0$ , and so in others higher. As also it's clear from these *Calculations*, that the Force of the *Attraction* of the Plane upon the *Corpuscle*, at the same finite Distances decreases faster, or at a greater rate, when the *Powers* of the Distances are high, than when they are lower, or when  $n$  is a greater Number, than when it is less; thus at the same finite Distances, the Force of the *Attraction* is much less *proportionally*, when  $n = 3$ , than when  $n = 1$ , or 2, and so in others where the Difference between  $n$  in one Case and in the other, is yet greater.

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Lastly,

Lastly, Suppose the attracted Particle  $P$  and  $PAHah$  and  $PO$  to be the *Asymptotes* of the *Hyperbola*, whose *Ordinates* are proportional to the *Attraction* of a Particle at their respective



Distances from  $P$ , then if the *Attraction* be reciprocally as the Distances, having describ'd the common *Hyperbola*  $lIL$ , whose *Ordinates*

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*AHKM*, which when the Distance is infinite is, as the Ordinates *hi* and *hk*, i. e. as  $\frac{1}{Pa}$

and  $\frac{1}{Paq}$ , or as *Pa* to 1, that is, as infinite to finite. And when the Distance as 0, it is as 0 to 1. In the same manner, if the *Attraction* be reciprocally as the *Cubes* of the Distances, at the Contact the Force will be infinitely greater, than when the *Attraction* decreases as the *Squares*. If it decreases in a *Quadruplicat* proportion of the Distances, the Force at Contact will be infinitely greater, than when it decreases as the *Cubes*, and so on. So that if *n* be taken successively, as 1, 2, 3, 4, &c. the corresponding Forces at Contact will be as 0. 1.  $\infty$ .  $\infty^2$ , &c. And if we should compare the same Forces at an infinite Distance, they would be 0. 0<sup>2</sup>. 0<sup>3</sup>. 0<sup>4</sup>. &c.

Now to apply this to the *Cohesion* of Bodies: It's certain that the first Condition (*viz.* when the *Attraction* is reciprocally as the Distance between the *attracting* Bodies) cannot obtain in the *Cohesion* of Bodies; for the Difference between the Force, when the Bodies are in *Contact*, and when they are at some Distance from one another, in this case is so small, as does not answer the *Appearances*: for we find, that the Force whereby Bodies *cohere*, is very much greater, when they come to immediate

Con-

*Contact*, than when they are at ever so small a finite Distance from one another.

In the second Condition of the *Universal Law of Gravitation*, (*viz.* when the Force is *reciprocally* as the *Squares* of the Distance,) the Difference of the Force of *Cohesion*, between Bodies at immediate *Contact*, and of the same, at some Distance from one another, is greater than in the former Case; but not sufficient to account for this Difference observable in the manner of the *Cohesion* of Bodies. But if it were possible to gather by *Experiment*, the *proportion* of the decrease of this Force, in *cohering* Bodies, to the same, at some determin'd Distances from one another, that would give the Condition of the *Universal Law*. But it will be very difficult to make any such *Experiments*, because the Fluids which surround Bodies, upon the Surface of our *Globe*, get in between the Surfaces of Bodies when they are at any Distance, greater than the *Diameters* of the constituent Particles of these Fluids, and so by their lateral pressures, destroy the efficacy of the Force whereby Bodies *cohere*; thus the Particles of *Light*, and of *Air*, get in between the Surfaces of Bodies, remov'd at almost an insensible Distance from one another, and seeing *Light* and Bodies act mutually upon one another, and that the Particles of *Air*, endeavour to recede from one another, they render the efficacy of the Force of *Attraction* whereby

whereby Bodies *cohere*, altogether insensible at any Distances from one another, greater than are the *Diameters* of the Particles of these Fluids; and a Distance equal to the *Diameters* of such subtil Fluids, is too small to be distinguish'd by our Senses, howsoever assisted. After all, it seems pretty difficult, to conceive all the Varieties of *Cohesion* in Bodies, from that one Principle of *Attraction*, and the plainness of Congruity of Surfaces. For there is no one

Law of *Gravitation* comprehended in  $\frac{1}{x^n}$  ( $=y$ )

which will beget a Curve *IKLM*, that will answer both these Conditions,  $o \times AHIL =$  to something, and  $PA \times AHIL =$  to nothing; which it seems it must do to explain *Cohesion*. Besides, it would agree much better with the simplicity of Nature, if the general Law where  $n=2$ , which obtains in the Celestial Bodies, cou'd be made agree with the Appearances of *Cohesion*. It is not impossible, that the Attraction, which at contact in this last mentioned Case, is 1 or finite, at any Distance whatsoever that Human Experiments can determine or observe, may be so intirely destroyed by the Interposition of foreign Fluids (that are not subjected to any of our Experiments in exhausting, such as is Light, and perhaps a yet more subtle Fluid. *Vid. pag. ultim. 2d Edit. Princip. Newtoni*) acting in a contrary Direction, as to leave no remaining Force in it: Or  
perhaps

perhaps the Figures of the constituent Particles of Bodies are to be considered in the Affair of *Cohesion*, as well as the Law of *Attraction*, to give a satisfying Account of it.

§ XLIV. *Cohesion* in general, being suppos'd after some such manner as has been explain'd, it is no hard matter to understand *Elasticity*, which seems to arise from the same *Principles*, of smooth and plain Surfaces, and of some one or more of the mention'd Conditions of the *General Law of Attraction*. In bending *elastick* Bodies, we find the *Convex* side exceedingly stretch'd, insomuch, that by frequent and long continued Bendings, there become visible *Fissures* in the out-side, which no doubt were there before, or in the first Bendings, tho' not so large, as to be visible, as also we see the *Concave* side, mightily contracted, or its Parts forcibly press'd together, so as to run into Folds or lesser *Convexities*, on the in-side: the same thing happens, when two *elastick* Globes or Balls, strike against one another, only the *Convex* sides, are turn'd in towards their *Centers*; the Matter being thus, let us suppose, that two very smooth and plain square Surfaces, are join'd together, so that each Particle in these Planes, attracts another, by some one or other of the Conditions of the *General Law of Attraction*; if these Planes, by any external Force, were so separated, as to move upon a common side of the Congruent squares as an *Axis*, and  
tha<sub>t</sub>

that no foreign Fluid endow'd with a disjoyn-  
ing Force (such as *Air* and *Light* are) cou'd in-  
terpose to hinder their Action : it is certain,  
that the external Force which thus separated  
these Planes, ceasing to act, the *Attractive* Force  
wou'd immediately bring these Planes together  
again; and if these Planes were separated by  
a *parallel* Motion, if the Distance were so  
small, that no foreign Fluid could get in to  
hinder their Action, if the *separating* Force  
ceas'd, the *attracting* Force would act and bring  
'em together again; and in both Cases, with  
a Force which may be easily gathered from  
the Condition of the Law of *Attraction*, and  
the Distance of these Planes being given. Now  
all *Elastick* Bodies in their Actions upon one  
another, changing their Figures, must of ne-  
cessity have some of their Parts in these Acti-  
ons, separated by a *Parallel* or a circular Mo-  
tion about an *Axis*; or by a Motion after  
some manner compounded of both these, (for  
it is no matter after what manner they are dis-  
join'd, provided they be not separated so far,  
as to admit any foreign Fluid to enter, which  
may destroy the efficacy of the Force, whereby  
these Particles *attract* one another) If we then  
suppose the Surfaces of the Parts of *Elastick*  
Bodies, plain and smooth, and that they *at-*  
*tract* one another after some one or other Con-  
dition of the *Universal Law*; being separated  
by a foreign Force, they must (when that Force  
ceases)

ses) join together again with a certain degree of Force (which is to be estimated from the Distance and Condition of the *Universal Law* being given) and so will produce all the *Appearances* of *Elastick Bodies*:

It may be objected, that it does not appear from this Account of *Elasticity*, how a Spring should grow stronger the more it is bent, since in that case, the *Fissures* being made wider, the attractive Force ought to be less'n'd, and consequently the Power of *Restitution* ought to be so too. All I can say to this is, that there is a proper arrangement of the Parts to be brought about in *Elastick Bodies*, which may in some measure be more readily obtain'd or facilitated by use; as we see Watches go more regularly, smoothly and exactly after they have been us'd for some time; and it is pretty certain, that *Elastick Bodies*, upon this account, may run more readily into their Actions, when the Parts by use are form'd and fix'd in the Situation most proper for this purpose, which at first they may not so perfectly be, by reason of the solidity and firmness of the Parts of most *Elastick Bodies*: To confirm this, we see Springs by too long usage, when the Parts are too much worn out, and the Chaps and Fissures become too large and visible, decay and lose their Power of *Restitution*, like other Organical Bodies, which Time and too long use wear out and render useles for their intended purposes. But perhaps the *Appearances* of *Cohesion*

*hesion* may be more congruously accounted for, from a proper Conformation of Parts, and the Action of an *Elastick* Fluid, which owes its Nature to the *Centrifugal* Force of its Parts: But this I am not at leisure to explain in the Particulars. Upon such *Principles* may the *Elasticity* of *Tendinous* Bodies be explain'd, but it is not my Business here to descend into all the particular Circumstances. If *Elastick* Bodies observ'd one constant *Proportion* in their unbending, toward their bending Forces, it were easie from thence, to determin the Condition of the *Universal Law* by which their Particles attract one another; but perhaps some may think, there are as great Varieties in this as in *Cohesion*; I shall not therefore trouble the Reader, in this place, with the particular Consequences, from particular Conditions of the *General Law* of *Attraction*, but shall content my self to have laid down *Principles* upon which these intricate *Appearances* may be, in some probable manner, accounted for.

I would proceed to some of the rest of the *Appearances* of Nature, which might be accounted for from the same *Principles*, but that these already explain'd are most of what I shall make use of in the following Treatise, for which this *Chapter* was design'd only as a *Lemma*: Besides, that some of the rest will naturally come into the Subject of these other Discourses,

C H A P.

## C H A P. III.

*Of the Origin of the present State of Things,  
and of the Epicurean and Mechanical  
Hypothesis.*

§ I. **I**T is a little surprizing to see Men frequently contending and wrangling about the *Origin* of their several Families, and yet scarce any Body give Himself the trouble once seriously to consider or enquire how the whole Race at first became to *be*, whether it sprang from the *Earth* or dropt from the *Clouds*, when it began, or if ever there was a time when it was not; tho' these Enquiries be far more worthy a wise Man's pains than those insignificant Contests. We are easily satisfy'd we and our immediate Parents have not been for ever; but few of us go farther, we take this World as we find it, without troubling our Heads *who made it*, or whether it was *made* or not. No Body can well bear to have their *Ancestors* affronted, nor their *Pedigree* despised; and yet very many now a days don't scruple to own themselves the *Children* of the *Earth*, or the Offspring of *blind Fate and Chance*. Whatever others may do, I shall not think my Pains ill bestow'd once in my Life to have examin'd

min'd, as far as my poor Abilities will carry Me; how this present state of things became at first to be.

§ II. There are three general Opinions about this matter, the first is of those of the *Epicurean* Sect, that holds that an *immense Void*, and an Infinity of differently figur'd, very small, extremely hard and infrangible *Particles of Matter* have for ever been; and that these Particles moving of themselves in a direction oblique to one another, after innumerable *recounters*, did at last settle in this *beautiful order of things* we now behold. This is a *Scheme* upon which some build their *Hopes*, and upon the account of which some of our *Moderns* think themselves subtil *Philosophers*, how justly we shall now examine.

§ III. First this *Scheme* supposes Matter to have for ever been of it self, without any Cause; which is a very liberal Compliment to such an unactive inanimate Mass, to make it independent for its Being and uncapable of being destroyed (both which *Self-existence* necessarily implies) *that is* to make it necessary, *that is* to make it infinite and eternal, and to raise it to a very high pitch of Dignity, to which we find none of its other qualities answerable. *Time and Space* or something *Analogous* to what we call by those names, it's true may have for ever been; but that is because they may have some relation to a Being endow'd with all other suitable qualities; but Matter seems to be too ignoble a Being to

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arrogate such high *Endowments*. But pass we over this Head at present, as not essential to the Business in Hand. And,

§ IV. Let us consider how out of these few *Principles* of an *immense Void*, an infinity of very small, hard and infrangible *Particles*, and their *oblique Direction* to one another, it is possible to form this present State of things. We have prov'd, § XI. of the preceding *Chapter*, that *Motion* is no more *essential* to Matter than Rest; that of it self it can never bring it self into Motion; that it would for ever continue in the State it is put in, and, if it was from all Eternity at Rest, it would continue so for ever; if in Motion, it would for ever move on. Now this being the Case, it would have been a great advantage to their Opinion, could they have shown whence this Motion did at first proceed; since it is suppos'd there is nothing beside unactive Matter it self to produce it. Whatever can be suppos'd to put Matter in Motion, may at the same time, and with the same ease, be suppos'd to have directed the several Parts thereof to the Places they are now in, *i. e.* to have produc'd this *present State of things*. No Body can think Motion *essential* to Matter, who sees any Part thereof at rest; for what is *essential* to any thing, that thing can never be without it. But some *Philosophers*, and those of great Name too, have asserted, that no part of Matter ever was nor can be

at absolute rest. For, say they, Motion is a Quantity, and may be divided *in infinitum* as well as other Quantities, and a Body may be moving any finite time, and yet never sensibly change its *relative* Place; for the Space is as the Velocity, and if the Velocity be very small, the Space it moves through is so likewise: And they alledge, that those Bodies which seem to be at rest, are only alternately moving very slowly to and from the *termination* of the Motion, or the *Obstacle*. To this I answer, that tho' it may be very true, that nothing in this Universe is actually at *absolute rest*, but that every thing is in some degree of Motion; yet that absolute Rest in Bodies is not impossible, is clear from hence, that it implies no Contradiction: A Sphere in a Vacuity should be press'd by two other equal Spheres, with equal Forces and contrary Directions, from which pressure the intermediate Sphere would be at *absolute rest*; wherefore, if it is not absurd a Body should be at *absolute rest*, it is impossible Motion should be *essential* to Matter. There is another Argument, which to me seems very conclusive against Motion's being *essential* to Matter, and that is, from the infinite possible Varieties of its Directions; laying aside the consideration of all other Bodies, or supposing a Body moving *in vacuo*, it must move in one certain *Direction*. Now what is it that determines it to this *Direction* rather than

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different *oblique Directions* to one another, by which means they would meet, and jostle, and reflect, innumerable different ways. But does not every Body see, that it is as easie and as intelligible to suppose this World already in Being, as to suppose these Particles endow'd with this *obliquely* directed Motion, the Cause of the one being no less accountable from their Principles than the other. We see all Motions now perform'd in the same Direction with that of the moving Force, and all Motions produced by the same *adequate Cause* have the same *Directions*; and consequently, if the Motion of these Atoms arises from themselves, they must all follow the same *Directions*, *i. e.* they must all move in *parallel Lines*; and consequently, they could never meet in order to produce any regular Effect. It is surprizing we should not find that Matter or Bodies now can alter their Directions, and yet, according to the Opinion of these Men infinite Ages by-past, they have mov'd as they list'd. Why do they not so still? Since (according to their own Supposition) nothing has happen'd to alter their Nature, or the manner of their Motions ever since; it is altogether unaccountable why Matter should move in one *Direction* rather than another, upon any other account but the *Direction* of the impress'd Force; and all that's alledg'd on this Head by the *Favourers* of this *Scheme* is altogether *precarious* and *absurd*.

§ VI. But

§ VI. But allowing these *Atoms* to be *self-existent, self-moving,* and *obliquely* directed, yet 'tis still inconceivable how they should produce a World. For these *Atoms* could not move all with the same degree of *Obliquity* to one another, for that would be making 'em all *converge* to a Point, and so nothing but one great solid Sphere could be produc'd, if they happen'd to unite after their meeting: And if they again reflected from one another, they would produce a fluid Sphere, their *rectilinear* Motions turning into circular ones, or otherwise would wander on in right Lines as before. And to make some converge to one Point, others to another, is to say, these *Atoms* were intelligent free Beings, which could chuse the Course they would go in. We have a very powerful Proof of the insufficiency of these *Atoms*, tho' endow'd with their *obliquity* of *Direction* to produce any thing, in the Rays of the Sun; which, as was before prov'd, are very small Parts of Matter, by the interposition of the Surfaces of reflecting Bodies differently situated, obtaining all possible varieties of *Obliquity*; and yet these produce no regular *Systems* of Bodies, tho' they move and probably jumble and interfere all imaginable ways. As I have just now said, those only whose *Directions* converge to a Point, could meet to produce any real Body, and even the Body which would be produc'd would only be a *sphere*

*rical* one. So that out of all their Motions, only *Spheres* of different Magnitudes could be form'd, which how small a part this is of the infinite variety of Bodies in this Universe, I leave the Reader to consider. The Truth of the matter is, if Bodies were *self-moving*, they could move what way they pleas'd, and stop when and where they pleas'd, *i. e.* they would be free-will'd *Elective* Agents.

§ VII. Again, allowing these *Atoms* to be *self-existent*, *self-moving*, and *obliquely directed*, yet I would gladly know, how from thence this *Universe* could be fram'd. It is not enough to say barely these *Atoms*, thus dispos'd, would at last settle into this State of things, unless it be shewn by what particular *Motions*, *Directions* and *Reflections*, the principal Bodies of this Universe were fram'd. To shew a thing possible to be done, we must tell how, what way, and by what Laws it may be done. For unless we descend to Particulars, we are never certain it can be so; and 'tis as probable (till the contrary be evinc'd, in some Particulars at least) it may not be so. *Generals* are always to be suspected; a Contradiction may be discovered in the particular Explications of an Appearance that was not taken notice of in the *general Scheme*; as indeed it happens in every individual Instance of this present Subject hitherto attempted. I shall not ask of those who defend this *Scheme*, a particular account of  
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of the *Mechanism* of every individual Appearance in our *System*, for that indeed were endless: But if any one can tell by what *Laws* of *Mechanism*, any one Animal or Vegetable was produc'd, or from what mechanick Principles the Planets describe *Elliptick* Orbits, I shall for the sake of these allow their whole *Scheme* to be true. We all know how wretchedly *Des Cartes* (the ablest *Patron* that ever this Opinion had) has blunder'd on these Heads, and his Followers have not mended the matter much. It is surprising to think how any reasonable Man could believe this *Universe* to have been produc'd by Matter and Motion, when as yet no Man that ever liv'd, from these Principles alone, can tell by what *Mechanism* the most contemptible of the *Celestial* or *Terrestrial* Bodies could be produc'd; and yet to be fully satisfy'd of the Truth of this *Hypothesis*, a Man must understand the particular *Mechanism* of the whole *System* of Things, and of every individual Appearance.

§ VII. These *Atoms* are suppos'd *infrangible*, extremely compacted and hard (as indeed the least Parts of Matter must necessarily be) which *compactness* and *hardness* is a demonstration, that nothing could be produc'd by 'em, since being so, they could never come to cohere, in order to produce solid Bodies. The only tolerable account of *Cohesion* in such like Parti-

cles, is from their branch'd Figure. Now hard solid Particles reflecting from one another, can never possibly lay hold of one another, at least not so but that the least Motion will disjoin 'em again. It is impossible to conceive, how innumerable hard and compacted *Atoms*, swimming in an immense *Abyss*, could ever come to cohere, so as to produce such hard Bodies as *Diamonds*, and some other *Mineral Substances* are, without any other cement but their catching hold of one another; this mutual embracing might keep 'em from being easily torn asunder, but they would be still moveable like chain'd Work, and could never produce the appearance of Firmness and Solidity. And what is here said of Cohesion and Solidity, may be likewise shewn of Elasticity. And thus allowing these *Atoms* to be *self-existent*, *self-moving*, and *obliquely* directed, and to meet according to any Laws of *Mechanism*, yet they could only produce loose heaps of *Atoms*, or such moveable ones that are altogether unlike the solid Bodies we now behold. So that to account for the production of this present State of things, besides their Matter and Motion, the *Abettors* of this Opinion want a Principle for Solidity, or Cohesion and Elasticity; both which are owing to no essential Property of Matter, as is shown in the two last *Sections* of the preceding *Chapter*.

§ VIII. There are several *Appearances* absolutely unaccountable from the Laws of *Mechanism*, and consequently, these could never be produc'd by Matter and Motion alone, or any *Combinations* of 'em. It were endless to alledge all the Instances that might be brought on this Head; some few of the most considerable will suffice; for if any one be inconsistent with the Laws of *Mechanism*, then it is impossible this *System* could have been produc'd by the concurrence of *Atoms*. The first I shall instance in, is that great Law to which all the Bodies of this Universe seem to be subject, *viz.* That of *Gravitation*. In the former *Chapter* I have endeavour'd to shew, that this Property is not *essential* to Matter, nor can arise from the Figure, Texture or Motions of its Parts, but is *implanted* therein by some Power superior to that of Matter; whence it is evident, that one of the primary Attributes of Matter is independent of the Laws of *Mechanism*. That active Principle which animates, as it were, the dead Mass of Bodies, and which is the Cause of all the beautiful *Appearances* of Nature, owes its Origin to something different from Matter and Motion, and therefore this *System* of things could not arise from thence.

§ IX. Not only *Gravitation*, or that implanted Principle whereby Bodies tend towards one another, is above the Powers of Matter, but all the Effects and Appearances that necessarily

cessarily depend thereupon, *i. e.* all the *Celestial* and *Terrestrial Appearances* are likewise above the Powers and Laws of Matter and Motion. All the Attempts of others before Sir *Isaac Newton*, to explain the regular and constant *Appearances* of Nature. were most of 'em *Ungeometrical*, and all of 'em so inconsistent and unintelligible, that it was as hard to allow their *Postulata*, as to conceive the thing which they pretended to account for from them. All the *Philosophers* that ever were, could never from the meer Laws of *Mechanism*, explain how the Planets came to move in *Elliptick* Orbits, they might (if Matter had been self-moving) have for ever stray'd in right Lines; but, that they should constantly revolve in Orbits, that they should approach to and remove from a determin'd Point at different Seasons, and that uniformly and constantly, is altogether unaccountable from the Laws of *Mechanism*, as has been shewn in the former *Chapter*. But from this implanted Principle of *Gravitation* (supposing they are already put in their Motions, and that all the *Celestial Machinery* is now actually in motion and at work) all the *Phenomena* are accounted for, and that to the greatest nicety we are capable of distinguishing. So that not only this Universe could not have been produc'd by the Laws of *Mechanism*, but there is scarce a single *Appearance* that can thence adequately be accounted for.

I have already distinguished between the *Laws of Creation*, and that of *Nature*: The first are the Laws observ'd by the *Universal System of Things*, whilst it was in *Fieri* (as the Schools speak); the latter the Laws of the Actions of Bodies, when it (the System of Things) is in *Facto esse*. The first are quite different from the latter; for tho' Matter and Motion might help us to explain some small part of the Appearances, now Things are actually constituted; tho' even this be false, yet these, with all the Laws of Nature, and throwing in *Gravitation ex abundantia*, will never help us to explain one single Appearance of Creation, Original Production, or the Primitive Formation, Adjustment and Arrangement of the greater or smaller integral Parts of this *System of things*. Can any one tell from these Principles, how the Figures of the Bodies of *Sun, Planets* and *Satellites* were rounded into their particular *spheroidical Orbs*? How the Kinds and Positions of their *Orbits* were determin'd? Whence their Number, Magnitudes and Density came? They may continue their Motion in empty Spaces, and describe their determin'd *Orbits* by the Laws of *Gravitation* and Nature, but by these they could never have acquir'd their present regular Form and Situation. The six principal *Planets* revolve in Circles *Concentrick* with the *Sun*, in the same Direction of their Motion, and in the same Plane nearly:  
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The ten *Moons* or *Satellites* revolve about the *Earth*, *Jupiter* and *Saturn*, in *Concentrick* *Circles*, and the same *Direction* of their *Motions*, in the *Planes* of the *Orbits* of their *Planets* nearly. But these regular and comely *Motions* could not arise from *Mechanical* *Causes*, for the *Comets* move in *Orbits* extremely *Eccentric*, and in all the *Points* of the *Compass*, which it is impossible they should do, did they revolve by the same *Mechanical* *Causes*, by which the *Planets* move: it is absolutely impossible once to imagine, the *Parts* of *Light*, and the other *Fluids* of our *System*, should have been form'd by the *Laws* of *Mechanism*. In a word, one single *Atom* of *Matter*, in its original *Production* and internal *Constitution*, is not to be explain'd from these *Principles*: and if the wisest *Philosopher* now being, will give a satisfactory account of any one *Portion* of the whole *System* of *Creatures*, from these *Principles*, as to its original *Production* and internal *Constitution*, I will, for the sake of this, give up the whole *Cause*; and yet to satisfy himself, he ought to account for the whole from them.

§ X. The *Production* of *Animals* is altogether inconsistent with the *Laws* of *Mechanism*.  
 1. The *Blood* is squeez'd by the *Force* of the *Heart* from the left *Ventricle*, through the *Arteries* unto the *Extremities* of the *Body*, and is thence return'd by the *Veins* into the right  
*Ven.*

*Ventricle*; thence by the *Arteria Pulmonalis* unto the *Lungs*, from the *Lungs* by the *Vena Pulmonalis* to the right *Ventricle* again. The Motion of the Heart is caus'd by the nervous Fluids, acting some how upon or with the Blood in the *Muscular* part thereof. And these nervous Fluids seem to be both deriv'd from the Blood, and forc'd into the *Muscular* part of the Heart, by the Motion of the Heart it self, the Texture of their containing Vessels, and perhaps by the Pulsation of the Arteries upon the Nerves in the Brain. Here now the Heart is the Cause of the Motion of the Blood in the Arteries, and the Motion of the Blood in the *Arteries* urging their Juices through the Nerves, is the Cause of the Motion of the Heart, which is a plain *Circulation of Mechanical Power*, *i. e.* a *Perpetuum Mobile*; which by what was said in the preceding Chapter, is contrary to the Laws of *Mechanism*. If an *Epicurean Philosopher* could contrive a *Water Machin*, that the *Water* should move the *Machin*, and the *Machin* the *Water*, so that the same *Water* should constantly return in a Circle to move the *Machin*; I should then think their *Scheme* somewhat feasible: But since the first is demonstrably impossible, the latter must be so likewise. 2. In all Animals there are *Organs* in number actually indefinite, if not infinite. By an *Organ* I mean a distinct independent part of a *Machin*: Thus a Wheel, and all its  
Parts,

Parts, is an *Organ* of a Watch, if I may speak so; and a *Gland* with all its parts, or a *Canal* from its Origin to its Extremity, is an *Organ* in an Animal Body. Now these *Organs*, or independent Parts in the Animal, are infinitely many, as is evident both from the Nature of *Sensation* and *Nutrition*. *Sensation* is perform'd by the mediation of an *Organ* arising from the Brain, and continu'd through the Part affected. Now there is not the least imaginable solid part of the Vessels or Muscles but is sensible, and therefore the *Organs* in Animals that convey this *Sensation*, are infinite in number. To this perhaps it may be objected, that one *Organ* may convey *Sensation* thro' several places, and consequently, tho' every minute part of the Body be sensible, it will not follow, that the *Organs* which convey this *Sensation* are infinitely many, since they may all be only the continuation of some few *Organs* through different Parts. But the Answer is obvious, if every Point of the Vessels and Muscles of the Animal Body be sensible, then the *Organs* which convey the *Sensation* are infinitely small, and if infinitely small they must be infinitely many, seeing their Extremities in the Brain constitute a finite *Superficies*, or fill a finite Space; for a finite Number of infinitely small Parts, can never make a finite Quantity. Again, *Nutrition* is perform'd by an *Organ*, through which the Supply is convey'd to the Place to  
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be nourish'd; and since there is no part of the Body that may not be increas'd or diminish'd (as is evident from the Cure of Wounds in all Places through which the necessary part of the Fluids of the Body can pass) it is plain, that every individual point of the Animal Body is the Termination of an *Organ*, through which the *Nutrition* may be convey'd. Moreover, seeing even the Canals themselves do increase in bulk, may decay and be impair'd, every assignable Part of these Canals must be the Termination of some *secretory Duct*, separating a Fluid fit to increase their Dimensions or repair their Losses; and these secretory Channels again, must have others to increase *their* Bulk or repair *their* Losses, and so on *in infinitum*. Add to all these, that the finest Glasses discover nothing in the several parts of the Vessels and Muscles but fine slender Canals, and the better the *Microscopes* are, the greater Number of those capillary Pipes are discover'd; and these Parts, which were formerly reckon'd *Parenchymatons*, are now found to be bundles or heaps of exceedingly small Tubes or Threads. The Muscles themselves consist of a number of Fibres, and each Fibre of an incredible number of little *Fibrils*, bound together and divided into little *Cells* or *Vesicles*: The *Glands* are nothing but a *clew* of little slender Pipes, diversly roll'd or folded together: The *Brain* is a numberless *Congeries* of infinitely small Tubes, woven

ven into several Figures: The *Nerves* are bundles of small *cylindrical* Pipes; and the *Lungs* and *Liver* are but Heaps of little Bladders, upon which the Blood-Vessels are spread in Net-work, or of little Glands among which these Vessels are dispers'd. In one word, all the solid Parts of the Body are nothing, but either very fine exceeding small Tubes for the conveyance of some Fluid, or slender Threads in Bundles ty'd together by others surrounding 'em, or going from one Fibre to another, or spread out into thin Membranes: For the *Bones* are nothing but such Bundles, and all the Membranes or Membranous Coats of the Vessels, are nothing but these Threads wrought together into thin Skins. From all which it is beyond dispute, That every Animal is made of Organs in Number really infinite. For these Organs become at last infinitely small, and so their Sum must be infinitely many, seeing it constitutes a finite Quantity. Now how ridiculous is it to imagine a Thing so wonderfully made could be the Effect of meer Chance, or of the blind Laws of Motion. In *Artificial Machines*, the more complicated and compounded the Contrivance of the Parts is, the greater the difficulty is in adjusting them; and the difficulty increases in the same proportion the *Complications* do, and consequently, when the *Complications* are infinite, the Machin is altogether above the Power of *Mechanicks*, and quite

quite impracticable by the Laws of *Matter and Motion*: But this is exactly the present Case, and therefore the Production of an Animal is altogether *immechanical*. 3. Allowing Animals might have been produc'd by the casual course of *Atoms*, why do not these very same Causes continually operate, and why do we not see the same Effects in our Days (since the Causes continue the same) that were beheld in former Times? If any of the *Philosophers* should shew us such an Appearance, nay, if they would but tell us (without running upon Contradictions) how such a *Machin* might be produc'd, we might begin to hearken to their Pretences. But since such a Thing was never seen nor pretended, it's very arrogant in them to think People should believe the Matter, without any Reason, upon their meer Word. No Body now-a-days, that understands any thing of Nature or *Philosophy*, can so much as imagin, that any Animal, how abject soever, can be produc'd by an *equivocal Generation*, or without the conjunction of Male and Female Parents, in the same, or in two different Individuals. And very few, who have consider'd the Matter, but own, that every Animal proceeds from a pre-existent *Animalcul*; and that the Parents conduce nothing but a convenient Habitation, and suitable Nourishment to it, till it be fit to be trusted with the Light, and capable of receiving the Benefit of the Air. We know ve-

ry well, that there is nothing in the *Animal Machin* but an infinity of branching and winding Canals, fill'd with Liquors of different Natures, going the same perpetual round, which are no more capable of producing the wonderful Fabrick of another Animal, than a thing is of making it self. Besides, in the *Generation* of an Animal, there is a necessity that the *Head, Heart, Nerves, Veins* and *Arteries* should be form'd at the same time, which can never be done by the Motion of any Fluid what way soever mov'd; for as hath been just now said, the *Heart* cannot move, unless Animal Spirits be sent from the *Head* through the *Nerves* into it: The Animal Spirits cannot be deriv'd into the *Heart*, unless the Blood be squeez'd by the *Heart* through the *Arteries* into the *Brain*. So that it is evident, that the *Head* and *Heart, the Arteries, Veins* and *Nerves* must be all form'd at the same time, if the Animal is *Mechanically* produc'd: But this is altogether impossible; for no Motion of any Fluid or Fluids howsoever dispos'd, can form all these at the same instant; and we know all the internal *Mechanical* Actions of Animals, are perform'd by the Force of their Fluids. Let any one consider the *Infinity* of Canals, and other Organical Parts in an Animal; and again consider, that all that one Animal can conduce toward the *Generation* of another, is by the force of some Liquors through some Canals, and try  
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if from this Power he be able to form the Idea of the *Generation* of an Animal. It is doing Pennance, to read the wretched Accounts of the wisest and most learned *Philosophers* on this Head: To observe, how in every step they contradict the known Laws of Motion; and indeed, the manner after which they would have 'em generated, is as much above the Power and beyond the Laws of *Mechanism*, as the true and genuin Manner and Method of their Production is. From all these Considerations it is evident, that an Animal cannot be produced mechanically; it is too hard a Problem to be solv'd from so few *data* as Matter and Motion; for indeed, could this one be once solv'd by any of the *Philosophers*, we should be easily satisfy'd of the rest; tho' Plants, and all the vegetable Kingdom be liable to the same Difficulties, and furnish us with the same Objections; for they are indeed only Animals of a lower Rank. And could it be once prov'd, either by *Demonstration*, or by *Matter of Fact*, that a Plant or an Animal can be produc'd by *Mechanism*, *i. e.* Nature, or the Laws of Motion, the thoughtful parts of Mankind would be easily tempted to believe, that since the better part was produc'd by Mechanism, the meaner, *i. e.* all the rest of this visible World, might have been form'd the same way. So that it is a Matter of the greatest Consequence, that we have demonstrated, that neither Ani-

mals nor Vegetables can be produc'd *Mechanically*. There are many other Arguments which I can produce, to prove the same Proposition, which the Language I write in will not permit me to set forth.

§ XI. The *Spontaneous* Motions of the sensitive part of this *System*, is an eternal Contradiction to the Laws of *Mechanism*. We have sufficiently shewn, that neither *Spontaneous* (nor indeed any) Motion is essential to Matter; it is determin'd to one Direction (while in Motion) which it can no more alter than move of it self. This our Senses may daily inform us of: The Ball goes on in the Direction of the Stick, or of the Body of the Piece out of which it is shot; the Arrow in that given it by the Bowstring; and the Hand of the Dial-Plate in that given it by the Wheels; and that necessarily and constantly, if not forc'd out of the same by some foreign Violence: But all *Sensitive* Animals have a *self-motion*, can turn and wind, move thro' all the Points of the Compass, go back and forward, as their Occasions require, or Inclination prompts 'em. It's true, some of our Modern *Philosophers* have asserted, that the *Brute-Creation* are only Pieces of Clock-work, and all their Motions are as necessarily determin'd as that of the Hand on the Dial-plate; but this Assertion is altogether precarious, and maybe deny'd as easily as its alledg'd. Besides, the Demonstrations *à priori* I have just now brought

to evince the contrary, the Observation and Experience of all Mankind contradicts it; the *Docility* and *Sagacity* of some Animals demonstrate the contrary, and some *Brute-Animals* shew more Indications of it than some of the Race of Mankind on whom they bestow it. What more evident Proofs of a *spontaneous* Motion could these poor Creatures give than they do, if they were really suppos'd to be endow'd with it? Nothing but a Sensation in our selves of the *Principle* of their Actions could create clearer Evidences of a *spontaneous* Motion. Besides, it is altogether impossible to account for the far greater part of their Actions and Motions from *Mechanism*, as we have in the preceding Propositions shewn at large. And we should be strangely surpriz'd, if by any Combination of material Organs, we should produce the smallest part of their Actions and Passions. Wherefore, since the sensitive World is endow'd with *spontaneous* Motions, and since this is far beyond and above the Powers of Matter, it is evident this Universe could not have been produc'd *Mechanically*.

¶ XII. The *Voluntary Motions* of Rational Creatures are altogether unaccountable from the Laws of *Mechanism*. Muscular Motion is perform'd much after such a manner as this: (If the most probable of our Modern Conjectures in this Matter have any Certainty in them) the Muscles are Bundles of Fibres, which

being closely compacted at both ends, terminate in their two *Tendons*, each of which is inserted into some one fix'd part of the Body or other: Every one of these Fibres consists of a prodigious number of lesser Fibres, or *Fibrils*, which are so many very slender elastick Canals bound about by small transverse parallel or Spiral Threads, which divide these hollow *Fibrils* into so many elastick *Cystes* or *Vesiculae*, as if a Gut were ty'd at equal Distances. Into every one of these *Vesiculae*, an Artery, Vein, and Nerve enter; the two first to bring and carry back the Blood, the latter to carry thither likewise its proper Fluid or Spirit; which mixing in the *Vesiculae* with the Blood, produces a Rarefaction (the manner how, for avoiding Disputes, I shall forbear at present to determin) whereby these *Vesiculae* are distended, and their *Longitudinal Diameters* (from Knot to Knot) straitned, and so the length of the whole Muscle shortned. The Nerves are the *secretory Ducts* of the *glandulous Substance* of the Brain, and consequently, are much of the same Nature with the other *Excretories* of the Body, which are nothing but small slender slips of the Arteries, for deriving an appropriated Juice or Spirit from the Blood. Wherefore, since the nervous Juice or Spirit is form'd out of the Blood, and since the Nerves are very small arterial Tubes this Spirit very probably must move in these Nerves after the same manner the Blood does in the Arteries, only with this difference, that it  
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moves abundantly more flow (its Velocity being abated, either by the many Circumvolutions of the Artery in the *Gland*, which is the Origin of the Nerve, or by the resistance the Juice meets with in the slender Pipe of the Nerve it self). If the *Circulation* of the Blood be admitted, and all the Juices of the Body be allow'd to be deriv'd from it, 'tis impossible that any of these Juices should stagnate in their Vessels longer than till they be fill'd; and therefore, the nervous Juice in its Channels is prope'll'd after the same manner and by the same Mechanism the Blood is urg'd forward in the Arteries. Now in the Muscles of involuntary Motion, such as the Heart, the Lungs, the Stomach and Guts, and the muscular Coats of the Vessels, this nervous Juice or Spirit is constantly derived by a *Mechanical* Necessity. In the Heart, while the *Auricles* are full of Blood, they are distended, and the influence of the nervous Juices into their Muscles thereby stop'd; but when once this Blood begins to flow into the *Ventricles*, the resistance arising from the distension of the *Auricles* to the influx of the nervous Juice is taken off, and so it flows into the muscular Substance of the *Auricles*, and thereby they are contracted while the *Ventricles* are distended, and the influx of the nervous Juice into their Muscles is thereby stop'd, till the Blood be deriv'd into the *Aorta*, and the impediment from this distension to the influx of the nervous

Juice be taken off, and so the *Ventricles* come into Contraction; which hinders the Blood from running any more into the *Ventricles* from the *Auricles*, and then the *Auricles* are again filled: And thus, by a *Mechanical Necessity*, they act *alternately*, the *Auricles* and *Ventricles* being as it were *Antagonists* to one another; so as that while these are distended those are contracted, the distension of the first permitting the influence of the nervous Juices into the latter; and so on the other hand. After the same manner are the *muscular* Coats of the Blood-Vessels' and of the Coats of the other Vessels containing Liquors deriv'd from the Blood, *alternately* contracted and dilated; for by the Contraction of the Heart the Blood is thrown into the Arteries, which distends them, and so the influence of the nervous Juice into their Muscular Coat is hindred; but when the Blood is by the *impetus* it has conceiv'd, deriv'd into the Veins, this impediment is taken off, and the Muscular Coats of the Arteries then act, the *Membranous* by their *Elasticity* concurring. In the Lungs the Gravity of the *Atmosphere* forces the Air into the small orbicular Vesicles thereof, and dilates the Cavity of the Breast; whereby the pressure of its sides upon them, and the Nerves that act in this Function is taken off, and so the Muscles of the *Diaphragm* and the other concurring ones are at freedom to act, and to distend the Cavity of the *Thorax*, till  
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the pressure of the sides of the Breast become too strong for these opposite combin'd dilating Causes; and then by their own Gravity, and the elastick Force of the Ribs, they fall down and compress the Lungs, and shut up the Emissaries of the Nerves. So likewise in the Stomach and Guts, when the *Longitudinal Muscular* Fibres are in Action, the *Transverse* and *Spiral* ones are relax'd by the pressure of the acting Fibres upon the Emissaries of the Nerves of the relax'd ones; and so on the other hand, when those are relax'd these are in action, and universally in all the *involuntary* Motions there is a *Mechanical* Necessity for the derivation of the nervous Juices into the Muscles employ'd in these Motions. But in voluntary Motions there neither is nor can be any such Mechanical Necessity, it being a plain Contradiction to their Nature; and therefore voluntary Motion is quite contrary to the Laws of *Mechanism*; we can move our Hands and Feet how and when we please in an instant, we can bend and unbend 'em as we will; there is no *Mechanical* Cause imaginable to force this nervous Juice into the Muscles of voluntary Motion, and no Motion can follow unless this Juice be deriv'd; as is plain from hence, that cutting the Nerves that serve any Muscle, tho' all other things continue the same, yet no Motion will follow. And the only Conception we can form of voluntary Motions is, that the Mind, like a skilful

fnl *Musician*, strikes upon that Nerve which conveys Animal Spirits to the Muscle to be contracted, and adds a greater Force than the natural to the nervous Juice; whereby it opens its Passage into the Vesicles of which the Muscular Fibres consist, which it could not have done by its natural Power. But this Action of the Mind or Will upon these Animal Spirits, being altogether unaccountable from the Laws of Motion, it is plain, that voluntary Motion is altogether *Immechanical*: And indeed, were it *Mechanical* it could not be Voluntary; for whatever acts *Mechanically*, acts constantly and necessarily, and so can never act voluntarily.

§ XIII. That *Freedom* and *Liberty* of choosing or refusing which we find in our selves, is altogether inconsistent with *Mechanism*. Some Men indeed deny that we have any Free-will at all; but these need only examin their own Consciences to be convinc'd of their mistake; they will find, that even when their Reason would determin 'em to do such a thing, they have in their Power to forbear it, or to do the contrary; they can rise or sit still, go backward or forward, to shew their own *Freedom*; they can chuse the Time and Place, the Degrees and Circumstances of all these Actions that are called Free. It's true, some of our natural Actions are necessary, but these which are commonly call'd voluntary Actions, are as much free as the nature of things will permit them.  
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Their Power being limited, I would gladly know, what greater *Indications* of Freedom they could wish to have, than they now have. The Passions of Mankind (which in most determin their Actions) are indeed violent, but they have it in their Power to suspend for some time the satisfying of them; which shews, they are not necessarily determin'd toward their Satisfaction; for the Action of necessary Agents can only be suspended by a Miracle. Let us suppose, that Man, in a perfect state of Health, is free, and has a Power of *Election*: The only *Indications* he could give of this Freedom are, by doing the contrary, where there are weighty and solid Reasons for doing such a thing; or by making an *Election* among many things, when there is no imaginable Reason to determin him more to one than another; or to be able to suspend the effect of natural Actions, when without this interposition they would *Mechanically* operate. Now it's certain that we are capable of giving all these *Indications*, to shew our Freedom: We have it in our Power to hurt or even destroy our selves, tho' there be the best Reasons in the World to hinder us from so doing, we can take out the one and not the other, in two or more of the same things in all Circumstances alike: Tho' *Respiration* be reckon'd an involuntary Action, and tho' it is certainly perform'd *mechanically* and uniformly, yet we have it in our Power to keep in our Breaths, and

and to suspend the efficacy of this natural *Function* for some time; and this seems to be one of the most evident *Indications* of Freedom that can possibly be desired: For tho' in other Cases it may be alledg'd, that it is the subtil and *imperceptible* manner after which we are determin'd, that makes any of our Actions seem free, yet in this Instance that Objection can have no place; for if we are determin'd ever so *imperceptibly*, it is by the Necessity of Nature we are determin'd. Now it is absurd to think, that Nature should determin any natural *Function* to be perform'd regularly and constantly the same way, and that by *Mechanical* Laws, and at the same time determin this *Function* to be irregularly and uncertainly suspended. On the other hand, if we are necessarily determin'd in all our Actions, and if we have no Freedom, it is absolutely impossible we should make any Election among things in all Circumstances alike; for if we are determin'd, it can only be from the things themselves without us, for all things within us are, upon this *Hypothesis*, to be suppos'd to move uniformly and *Mechanically*. Now where the things without us are in all Circumstances alike, we can never be determin'd to any one of 'em by themselves; and therefore were we not free, we could never make an Election among things altogether alike. By things altogether alike, I mean such as are alike as to all the Circumstances necessary to  
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constitute them the things requir'd. Thus two Farthings are altogether alike, tho' they may differ in some small Circumstances that do not concern the *Essence* of that *Species* of Coin. Thus 1, 3, 5, 9, are equally odd Numbers, and 2, 4, 6, 8, are equally even Numbers, and if 'twere propos'd to assign an even or odd Number, there are infinitely many which are equally such. The same thing happens in the Answers to all these *Problems*, which are call'd *indetermin'd*; and in assigning one of the Answers to any such *Problems*, there is nothing in their Nature that can possibly determin us, the Conditions of the Problem being had respect to; and therefore such things as these are only pitch'd upon by the energy of our Wills or Freedom. In a word, *Freedom* consists not in doing any thing, or every thing, for thus even the *Supreme Being* is not free, it being impossible for Him to do Evil; but in varying and diversifying infinitely different ways, the Manner and Circumstances of what may be done, and chusing without constraint, or from any Motive foreign to the Party chusing. But no Arguments will make a Man confess he feels, if he be obstinately resolv'd not to confess it: now Liberty is a thing felt, and is only to be found by a *Reflection* on our selves and our Actions; but there is one Argument which will always have weight with the wiser and better part of Mankind; and that is, that without Free-will, Virtue and Vice, Justice and Injustice are only bare

bare Words. Now if Rational Creatures be free, as most certainly they are, this Freedom is a plain downright Contradiction to *Mechanism*; for *Mechanism* produces all its Effects necessarily.

#### C H A P. IV.

*Of the Eternal Production and Duration of this present State of Things.*

§ I. **H**AVING, I think, sufficiently shewn the Inconsistency and Impossibility of the *Epicurean Scheme*. I come to the second Opinion about the *Origination* of the Universe; which in few Words tells us very positively; “That this present state of Things has been from all *Eternity* of it self, so as we now behold it; and that any Changes that have happen’d therein, have proceeded from the Laws of *Mechanism* that now obtain in the World.” This *Scheme* consists principally of these two Parts. 1. That this World has been for *ever* in the State we now behold it. 2. That it has been so for *ever* of it self, independent of any other Cause. This Opinion is commonly, but falsely ascrib’d to *Aristotle*, not as its first *Broacher*, but as its ablest *Patron*. But tho’ *Aristotle* held the first part of it, *viz.* That the World was from all *Eternity*, as we now behold it, yet he did not think it was so of it self; and there is a very great

great difference betwixt allowing this present *System* of the *Universe* to have been created from all *Eternity* by an *Omnipotent Cause*, and believing it to have been for *ever* of it self without any *Cause*. My Design in the following Discourse, is not to dispute against any *Scheme* of those who admit the Existence of a *Deity*; I intend only to shew, That this present state of things could not have been from all *Eternity*, neither of it self, nor without the frequent and particular interposition of a *Divine Power*, and to make it plain, that naturally, and of it self, it tends to *Dissolution*: Tho' in the mean time, it is not to be doubted, but that that *Almighty Power* which could create this *beautiful System* of things, can preserve it in being as long as He pleases.

§ II. That this Universe could never have been from all *Eternity* of it self, in the present Condition it now is, is evident from hence, that it requires an *extrinsick Principle* for its subsisting in its present Condition. If one should see a Piece of *Clock-work*, pointing out the Divisions of Time exactly and regularly, he might have some Difficulties about the manner of its Production; but if he should see or learn, that it requir'd some *Foreign Assistance* to keep it going, that its Motion depended upon some Principle without it self, that it requir'd winding up of the Spring or Weights, he would be soon satisfy'd it could not have been from all

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*Eternity* of it self in the state he then beheld it. Now this is the very Condition of the *Earth*, the *Moon* and *Planets*, and of all the *Celestial* and *Terrestrial* Appearances: Their Motions and Actions depend upon a Principle quite *extrinſick* to Matter, which ariſes from none of its Powers or Properties, as has been ſhown in the former *Chapter*. The Power which produces and preſerves their Motions, ſprings from ſomething without themſelves; and if this Power were ſuſpended or withdrawn, they would immediately ſtop, and their Motions would be deſtroy'd, and they would become a lifeleſs unactive heap of Matter. And this Power is nothing elſe but that univerſal Law of *Gravitation*, which *actuates* the whole Frame of all the *Systems* of Bodies, which proceeds from a Source both independent of, and diſtinct from Matter and all its Faculties. Wherefore, it is altogether impoſſible this preſent ſtate of things ſhould have been from all *Eternity of it ſelf*, ſince at preſent it cannot ſubſiſt in a regular and beautiful *System*, without the perpetual influence of ſome ſuperior and *extrinſick* Power.

§ III. When one thing depends upon another thing, as its *Cauſe*; as alſo, when one thing is neceſſarily requir'd for the Exiſtence or Preſervation of another thing, theſe can hardly be ſuppoſ'd to have been from all *Eternity of themſelves*; but much more likely ſeem to imply  
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Counsel and Design, and consequently, to flow from the Wisdom and Power of some *Intelligent Being*: For *Self-existence* necessarily implies Independence, as to Existence on any other thing, either as Cause or as Effect; (I mean only of those things which are about us, *viz.* the visible things of this World, which have but Qualities both finite in Number and Degree; and consequently, have *assignable* relations to, and dependences upon one another; for it is otherwise in the *Immense Being*, in respect of his Creatures, which can have no proportion to Him, and He no dependence on them) and when a thing depends upon another thing as its Cause, this implies, that the first thing exists that the second *may exist*; which supposes Design and Contrivance, and consequently is a sign of Production or Creation, and not of the Self-existence of these things. Likewise, when a thing is necessarily requir'd for the Existence or Preservation of another, it plainly implies, that the first thing exists that the second *may exist*; which likewise supposes *Design* and *Contrivance*, and consequently, can be no sign of *Self-existence* in these things. Now is there any thing more plain, than that most of the things in this our *System* are necessary or useful towards the Being or Preservation of *Mankind*? Remove the *Sun* from us, or us from the *Sun*, the Earth could bring forth no Fruits for our Support; take away the *Moon*, the

*Seas* would stagnate and the Fish be destroy'd; level our *Mountains* we should have no fresh Waters; destroy our *Atmosphere*, or the Air's Elasticity, we should swell like poison'd Rats. Do not these, and a thousand other Instances I could alledge, demonstrate, that all the Beings of this Universe exist as the necessary Effect, or for the Existence or Preservation of other Beings, and consequently, imply *Contrivance* and *Design*; which is a most evident sign, that all these things have been produc'd, and are not Self-existent. If a wild *Scythian* or *Indian*, who never saw a House in his Life, should meet with a *noble Palace*, neatly finish'd and finely furnish'd, and about it should find Creatures that could not subsist without such a Convenience, and should plainly discover, that the Accommodations and Conveniencies of this *Building* were exactly suited, in every Circumstance, to the Wants and Necessities of these Creatures; I think he would have no difficulty in concluding, that this House was built by some wise *Architect* for the Convenience of these Creatures, he would certainly never dream, that it had for ever been there of it self so as he then beheld it. Now this is the very Case betwixt us, and the *System* of things about us: They have all relations and regards to us in our present state, and to one another; there is a regular Subordination and Subserviency among all the Parts, they all conspire to great  
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and beneficial Ends: In a word, There is not so much as a supernumerary, superfluous or useless *Atom* in the whole great and complicated *Machin* of the Universe; every Age discovering new *final* Causes, and every the least Object displaying some new Utility or Beauty, to those *who seek out the Works of the Lord, and take pleasure therein*: So that it is impossible, that those who with due Preparation apply themselves to them, should ever think they could be of themselves, or did not owe their Being to an *All-wise* and *All-powerful* Original. Not that the whole *System* of the Universe was contrived for the Race of Mankind alone; but that since their Utility and Conveniency being so plainly and fully consulted, in their present state, there can remain no doubt, that the whole *System* of Beings has been equally provided for in this wonderful Contrivance.

§ IV. That *Animals* could not have been from all *Eternity* is plain, for both the Reasons alledg'd in the two former *Sections*. For, First, Their Production and Existence depend upon Principles quite extrinſick from, and independent of themselves, I mean of their *Material part*. I have formerly shown, that they can neither subsist, nor be produc'd by the Powers of *Mechanism*; but for both require the constant influence of a Principle, even different from that which governs the inanimated part of the Universe, *viz. Gravitation*. Now all that

is observable in this World (according to this *Scheme*) is Matter and Motion (for if we once allow a Power distinct from these, we ruin this *Hypothesis*; for we do not then know how far the influence of this Power may reach, as to the Production and Preservation of the present state of things.) But the Production and Preservation of *Animals* is above the Powers of Matter, as has been formerly shown; and therefore, since they depend upon a Principle distinct from, and independent of the Laws of *Mechanism*, and need a continual influence of some Principle, distinct from Matter and its Properties, they could not have been for ever of themselves. Secondly, All the several Parts and Organs of the Animal Body, are so prudently adapted to the Benefit of the whole *Compositum*, as plainly implies Design and Contrivance, that it is impossible to consider this, and imagin they have been Self-existent. How wisely are the *Bones articulated*? How prudently the *Muscles* contriv'd, and how conveniently fastned to the several Places of the Body to produce the necessary Motions? With what Judgment are the *Arteries, Veins* and *Nerves* ranged? With what Wisdom are their Fluids dispos'd in their proper Vessels? How carefully is the Propagation of the *Species* provided for, according to several Circumstances arising from the particular Climate and Element each *Animal* is confin'd to, and how justly is every  
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Particular adapted for the benefit of the whole Compound? I shall have occasion to pursue these Instances farther hereafter; but any Body who is ever so little acquainted with the *structure* of an *Animal*, cannot but discover evident Footsteps of *Design and Contrivance* in it, and therefore *Animals* cannot be Self existent. These, with the preceding Considerations on this Head, make it very improbable, if not impossible, the present state of things should have been for ever of themselves, without an *Omnipotent and Omniscient Original*. I come in the next place to those Considerations that seem to imply, That this present state of things is naturally, and of it self, tending to Decay and Dissolution, and consequently, that it must of Necessity have had a *Beginning*.

§ V. It has been formerly shown, in *Section XXVIII* of the preceding *Chapter*, and its *Corollary*, that some part of the Nourishment of *Animals* and *Vegetables*, and the greatest part requir'd to the Production of *Minerals* and *Metals* is a watry Fluid, impregnated with some other Body, which, by proper Operations upon this Fluid, is chang'd into a solid Form, of which but a very small part is ever resolv'd into Water again, whereby the quantity of Water on this our Globe is daily impair'd and diminish'd; wherefore. if the World had lasted from all *Eternity* in the State it now is, we had long since wanted both salt and

fresh Water. This Decrease of watry Fluids on our Globe is so considerable, that Sir *Isaac Newton* makes one use of *Comets*, in regard to us, to be to supply the Earth and other *Planets* with proper Materials for this purpose: For as the *Sea* is absolutely necessary for the present State and Condition of our Globe, that from it, by the *Sun's* Heat, Vapours may be so plentifully rais'd, that being collected into Clouds, they may fall into Rains, so as to water and nourish the Earth, for the Procreation of *Vegetables* of all kinds: Or being condensed on the cooler Tops of Mountains, may fall through their Chinks into Basons and Reservoirs, form'd by their hollow and open Texture, and thence into Rivulets and Rivers. So likewise for the Supply and Preservation of the *Sea*, and other Fluids in the *Planets*, the *Comets* seem requisite, from whose condens'd Exhalations and Vapours, whatever Liquor is spent on Vegetation and Putrefaction, may be supply'd and restor'd; for all the *Vegetables* are nourish'd constantly by almost Liquids only, and from putrify'd Liquors there is a Slime constantly falling: Hence the Quantity and Bulk of dry Earth is continually increasing, and the Fluids, if they were not supply'd elsewhere, would perpetually decrease, and at last fail. Now wheresoever the Decrease of the Fluids be fix'd, whether in the *Planets* or *Comets*, it's plain they do decrease in this our  
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*System*, and consequently, had the World lasted from all *Eternity*, they must have fail'd e're now; for had the *Planets* wanted a regular Supply, since it is evident they have their Fluids continually turn'd into dry Earth by Vegetation and Putrefaction, had the World lasted from all *Eternity*, they had been more parch'd and dry than the Desarts of *Arabia* 'ere this time. But supposing their Supply regular from the *Comets*, and let these *Comets* be as many as you please, less than infinite, yet still, had the World lasted from all *Eternity*, these *Comets* must have been drain'd of all their Fluids, had they been nothing but Globes of Water, whereas we know they are Masses of solid dry Matter, like the *Planets*, with large gross *Atmospheres*: So that it's evident, the liquid Substance in this our *System* of Bodies is continually decreasing; which seems to imply, that this present state of things is not so contriv'd as to last for ever, and so could not have been for ever.

§ VI. It has been prov'd likewise in the preceding *Chapter*, That the *Light* of the *Sun* does daily decrease, and that the Body of the *Sun* does continually grow cooler; the same may be said of the *fix'd Stars*: Now had the *Sun* and *fix'd Stars* been from all *Eternity*, we should have been reduc'd long before this time to a state of utter Darkness. We are very certain, that the Rays of the *Sun* are imprison'd in our *Plants* and *Vegetables*, in our *Metals* and *Mine-*

rals, and are retain'd by the Action of Bodies upon Light; and some part of them by their Separation from others, and their being imprison'd in these Substances, and the Action of Bodies upon Light, are for ever hinder'd from returning to the Body of the *Sun*; even supposing it were possible, that any Rays emitted from that *Luminous Globe* could return thither again, which is not very probable, they being projected with such a Force and Velocity, and retain'd by the *Attraction* of Bodies, where any oppose their Course, and proceeding for ever in their *Rectilinear* Direction, where no Bodies obstruct them. We are certain likewise, that the *Fountain* of our Heat daily impairs; that the vast Body of the *Sun* is perpetually a-lessening and a-cooling; not only by the fuming away of his Parts, but by the nearer Approach and stronger Action of *Comets* in their *Perihelia*, which carry off great Portions of his Heat and Substance. It is very probable, that these Specks and Clouds which appear and disappear on the Face of the *Sun*, are Vapours which fume away, and fill the Spaces through which the *Planets* move, or are *attracted* by their *Atmospheres*; and the *Comets*, by their so near approach to the *Sun*, so as to enter into his *Atmosphere*, must, without all doubt, carry off considerable Portions of this Substance; insomuch, that Sir *Isaac Newton* is of Opinion, that these *Comets* may at last fall into his Body, to rekindle and supply

ply the Waste: and that those *fix'd Stars* that have disappear'd, and now appear, may be such-like *Suns*, rekindled by the Approach of a *Comet*, just returning with the fiery Spoils of the *Sun*. And tho' these Effects be not so considerable, as to become sensible in three or four thousand Years (tho' if ancient Histories be true, this abatement and diminution of the Light and Heat has not been insensible) yet, in an infinity of Ages (this diminution being still somewhat) the *Sun* had been reduc'd to the Heat and Light of a Taper long 'ere this time; and we had been involv'd in a more than *Cimmerian* Darkness. But since we observe no such Effect as this, it is plain the World has not lasted from all *Eternity*.

§ VII. But that which does infallibly demonstrate, that this present state of things both had a beginning, and that of themselves they must have an end, is, That our *Earth*, the *Planets*, the *Sun* and *fix'd Stars* do not move in Spaces altogether void, but in such that do make at least some resistance to their Motions, I have shewn in the preceding *Chapter*, that the Reason why, for example, the *Planets* move about the *Sun* is, that the Body of the *Sun* attracts these *Planets*, and likewise these *Planets* attract the *Sun*; and that (since the *Planets* describe *Elliptick* Orbits about the *Sun*) the attractive Force of the *Sun* upon the *Planets* is *reciprocally*, as the *Squares* of the different distan-

ces of the *Elliptick* Orbit from the *Sun's* Center in its *focus*. But that besides, these *Planets* were driven at first, or at the beginning of their Motion (to speak so) by a Force whose Direction made an Angle with the attractive Force; or that at the very same time the attractive Force of the *Sun* exerted it self on these *Planets*, they were push'd along in right Lines, by a Force whose Direction was in some manner or other inclin'd to that of the Direction of the attractive Force of the *Sun*, otherwise they could never have revolv'd in Orbits. So that it's evident, the Motion of the *Planets* about the *Sun*, is compounded of two different Motions in two different Directions, either of which being destroy'd, the *Planets* must have fall'n into the *Sun*, or stray'd for ever in right Lines; and tho' the resistance of the *Medium* cannot alter the *Centripetal* Motion, (so I call that whereby the *Planet* tends towards the *Sun*) yet if there be any resistance in the *Medium* through which the *Planets* pass, the *projectil* Motion (so I call the other) must decrease and (in an infinity of Ages) be destroy'd. Sir *Isaac Newton* has indeed demonstrated, that the *Celestial* Spaces thro' which the *Planetary* and *Cometary* Globes do move, must be void of all gross material Fluids, which might make any sensible resistance to them: For since all Fluids resist according to their Densities, or in proportion to the Matter they contain, as has been  
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already mention'd: And since no sensible resistance has been observed to the Motion of the *Planets* and *Comets*, but that they freely move through the Mundane Space, on all Hands, and in every Point of the Compass, without any sensible diminution of their Motion, of necessity the Spaces must be void of all gross and sensible Fluids: Yet in the present Argument, unless these *Celestial* Spaces could be demonstrated to be absolutely and *Metaphysically* void, in an infinity of Ages, some even sensible Resistance must have been made to their Motions. I readily grant, that the present Frame of things is so wisely contriv'd, that they may continue in their present Order, and obtain their appointed Ends for some thousands of Years, without any sensible Alterations, and that their Usefulness and Advantages do not depend on indivisible Points. But when infinite Duration is the Question, the Argument is considerably, if not infinitely alter'd. There are many Reasons for suspecting the *Celestial* Spaces, through which the *Planets* and *Comets* move, not to be absolutely void. *Light* is a Fluid, as has been demonstrated, and passes from the *fix'd Stars* to us, and from us to them, and through all the several *Systems*. The *Sun*, very probably, throws out some part of his Clouds and *Atmosphere* on the *Planets*; the *Atmospheres* of the *Planets* are elastick, and tho' doubtless very rare at great Distances from  
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the Surfaces of their Globes; so as that a *Sphere* of Air of an Inch *Diameter*, of the same Density as it is at the Surface of the Earth, if 'twere expanded as much as the Air is at the height of a *semidiameter* of the Earth, would much more than fill all the *Sphere* within the Orbit of *Saturn*: Yet still being elastick, they may transmit some thin Vapours into one another, as very probably they do, by all their (not altogether insensible) Actions on the *Animals* on our Globe. The *Comets* send Steams and Vapours from their Tails, sufficient to supply the Expences of the Fluids in the *Planets*, as has been just now mention'd. All of them, *Planets* and *Comets*, have some secret Influences and Actions upon one another, even different from the bare Action of their *Attractions*; all which make it very probable, if not demonstrable, that these Mundane Spaces are not absolutely devoid of some extremely thin and rare Fluid, whose Action, tho' not sensible in any finite time, must have been sufficient, in an infinity of Ages, to have destroy'd the *projectil* Motion; and consequently, long 'ere now all the *Planets* and *Comets* had been broiling in the *Sun*, had the World lasted from all *Eternity*; which not having happen'd, it's plain this present state of things has not lasted from all *Eternity*, in the Order we now behold it.

§ VIII. The real, tho' insensible Changes and Variations that happen to the *Celestial* Bodies

dies in this our *System*, in respect to one another, in their Motions, Bulks, and mutual *Attractions*, amount to a convincing Proof, that the present state of things was not intended to last for ever, and consequently, could not have been from all *Eternity*. The Regular Description of equal *Areas* in equal Times in the *Moon* (on which all the Philosophy of her Motions and Appearances depend) is somewhat disturbed by the Action of the *Sun*; besides innumerable other Variations in her *Theory*, which have not all as yet been intirely collected or adjusted: All which pretty nearly happen to the *Satellites*, with respect to their *primary Planets*: *Jupiter* and *Saturn* disturbing each others Motions near their Conjunctions; and these two greater ones disturbing the Motions of the lesser, *Mercury*, *Venus*, the *Earth*, and *Mars*; so that their *Aphelia* are continually changing in a progressive Motion forward. The reason why the *Comets* move not in the *Zodiack* as the *Planets* do, is, that in their *Aphelia* they may be at the greatest Distances from one another, and consequently, may disturb one another's Motions the least that may be, by their mutual *Attractions*; notwithstanding which they so far disturb one another's Motions, as scarce ever to return in the same Orbit, or in the same periodical time exactly. That the Motions of the *Planets* are, or may be disturbed by the *Comets*, in their return into the  
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*Planetary System*, is, on the Principles laid down in the foregoing *Chapter*, past all doubt; the Decrease of the *Sun's* Heat, Light and Bulk, and consequently, of his attractive Force, must at last lessen the mean Motion of the *Planets* about him, and consequently disturb, alter and change the whole state of the *System*. The Approach of some of the *Comets*, in their *Perihelia*, so near the *Sun*: the resistance they meet with in their Motion by the *Sun's Atmosphere*, in so near an Approach; and the disturbance and retardation of their Motions they meet with in their *Aphelia*, by their mutual *Attractions* (being so large in Bulk and many in Number as Observations show them) all these Causes, I say, co-operating, must at last so weaken their Motion, and gradually bring them so near the *Sun* in their *Perihelia*, that they must at last drop into his Body, which must produce inconceivable Changes in this our *Planetary System*. The Vapours and Steams sent from the *Atmospheres* of the *Sun* and *fix'd Stars*, and from the Tails of *Comets*, may, on the Surfaces of the *Planets*, be chang'd into Water and watry Spirits, and then by a show of Heat, may be turn'd gradually into *Salts*, *Sulphurs*, *Tinctures*, *Slime*, *Clay*, *Marle*, *Sand*, *Stones*, *Corals*, and other Earthy Substances, and so increase the Bulk, Weight and *Attractions* of these *Planets* upon one another; and Dr *Halley*, by comparing ancient and modern Observations, has

has found, that the mean Motion of the *Moon*, compar'd with that of the Earth, is actually increas'd; which would seem to imply, that the Weight and attractive Force of the Earth is actually increas'd. Now tho' all these Changes be insensible in some hundreds or thousands of Years, and tho' they be regularly irregular (so to speak) and proceed from constant and uniform Causes, yet, in an infinity of Ages, backward or forward, they must have made, or must make such Changes in our *System*, as would not suit with the present Constitution of the animate or inanimate kind of Beings now existing; and plainly show the present state of things not calculated for *eternal Duration*, in the Condition we now behold 'em, and consequently, that they could not have been for ever as they now be.

§ IX. I have observ'd in the former *Chapter*, That the best Image or Idea we could frame of the *System* of the Universe was, as of a *noble* and *immense Machin*, form'd upon the strictest Principles of a *Divine Geometry*, the Whole, and its several Parts adjusted by Number, Weight and Measure, all conspiring towards, and regularly attaining some great and magnificent Ends, whose Springs are an immaterial Principle (if I may so call that of *Gravitation*) which animates the whole and all its Parts; an Original Impress, or a constant efflux from the *Divine Energy*, which enables the whole,  
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and all the several Parts, regularly, constantly and harmoniously to attain their destin'd Ends and Purposes. There are certainly remaining, on all the Works of Nature, infinitely many and overcomingly strong and great Lineaments and Tracts of Wisdom, Contrivance and Design, so wonderfully beautiful and ravishing, that it must necessarily fill the Hearts of those *who take pleasure to search out the Works of God*, with Joy, Love and Veneration for their All-perfect Original. But there are many Suspicions arising from the present Constitution and Frame of the Universe; That it has already undergone, and may, for the future, undergo many Changes and Alterations from what it now appears; and consequently, that it has neither lasted from all *Eternity* as it now is, nor is likely to continue for ever in its present state. 1. Whatever else may be in this *System* of things, yet we are certain, its Parts and *Organs* are Material and Corporeal. Now it is not in the Nature of Material Organs to last for ever in the same state, especially if we join to this Consideration, that there is no perfectly solid and compact Bodies, but that all the Bodies we know of have interspers'd Pores and Vacuities, by which subtil Matter entering, must at last dissolve and destroy the Forms of Material Bodies; and the *Celestial* Bodies being, in reason, to be suppos'd of the same Nature with those about us, they must, in  
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time, moulder away, corrupt and change their Forms and Figures, and at last a sensible Alteration must be induc'd upon the Face of things thereby. 2. Whence soever the Motions of the *Celestial* Bodies did arise, or are continued, yet the Change on the solid Bodies of the *Celestial* Globes must make great Changes in their Motions: For tho' it were true (as it is much to be doubted) that no Motion is lost, yet if the Texture, Size and Solidity of the *Celestial* Bodies may be chang'd, there may such Changes ensue on the Constitution of the *System*, as may make it quite a different thing from its present state. 3. There are Suspensions, That the present *System* has undergone some considerable Changes (whether naturally or supernaturally is not the Question here) in respect of the present Set of Beings that inhabit, at least, our *Planet*. The Grossness, Opacity and Darkness at present on the Face of things, the dense and dusky *Atmospheres* about the *Planets*, the Inclemency of the Seasons, the Malignity in the Elements, the Poison in Animals, Vegetables and Minerals, all these seem to be the effects of some great Change induc'd on Nature, and not their State, as they immediately came out of the Hands of an infinitely wise, good, and powerful Being; and no Philosophy but that of *Christianity* can account for this, which acquaints us with the Degeneracy and Corruption of this present Set of

Beings, in withdrawing their Love and Desire from its proper Object, to wit, Infinite Perfection, and placing it on the Creatures, and thereby becoming gross, sensual, opaque, and irregular, and so rendring the Change of the then Constitution of things necessary. Add to these the *Elliptick* Orbits of the *Planets*, their *spheroidical* Figures, the Obliquities of their *Æquatorial* to their *Ecliptick* Planes, the ruggedness and deformity of their Surfaces, the Suspicions of some universal Change on the internal Texture, at least of our Planet, the distant wandring of the *Comets*, and the extinction and re-kindling of the *fix'd Stars*; all these, and many more, such as I could collect, seem in some measure deviations, from the Simplicity, Uniformity and Facility Nature would observe, if not forc'd out of her Measures, and are shrewd Suspicions, that some great Changes have been made upon the Original Frame of our *System* at least. Far be it from me from suggesting the least Hint towards lessening or depreciating the infinite Wisdom, Beauty and *Harmony*, undeniably appearing in all the Works of G O D: All I would insinuate is, that there seems to appear *Vestiges* of some Alterations in the Constitution and Frame of the Universe, (at least of that part of it which principally respects the Human Race) from its primitive Lustre and Beauty, and that *Paradisaical* State wherein our Holy Religion informs us it was origi-

originally constituted. The Scripture-Account of the Nature of glorify'd Bodies, and of the *Paradise of the Faithful*, as also, of the Labour and Groans of the whole Creation under its present state, accounts for what one who soberly and attentively looks into the natural Pravity of his own Heart, or into the present (in some small degree) Gloominess, Perplexedness and Distortion of our *System*, cannot help to observe. All which seems evidently to hint to us, that the present Constitution neither has lasted, nor is to last for ever.

§ X. If the *fix'd Stars* be not actually infinite in their Number, then this present state of things must, of necessity, both have had a Beginning, and must have an End. It's certain these luminous Bodies do mutually *attract* each other, since it's absurd to imagin Matter not to be of the same uniform Nature every where; and it's as certain, that they do not revolve about any common Center or Centers, since they have been observ'd never to have varied their Situations or Distances from each other. Now if they be finite in Number, the terminating Bodies of the material part of the World must be all free from Attractions towards the void part, and so must be all approaching towards the *common Center of Gravity* of the whole, and had the Frame of the World been eternal, they had long 'ere now all of 'em met there. *Space* indeed may be infinite in its extent, but

there is no imaginable Reason to believe the Number of the *fix'd Stars* is infinite, nor the material part of the Universe boundless, since we have very good Reason to believe, that the solid Substance has a very small Proportion to the Vacuities interspers'd even in our *System*, and that the Matter of this Universe is almost nothing in respect of the containing Space, as has been insinuated in the former *Chapter*. For since Space is infinite (as I shall hereafter demonstrate) and since there's a necessity of admitting of actual Vacuities, as I have formerly shown, it's plain, Matter cannot be infinite in its extent, since thereby it is not equal to *Space*. I very much doubt, whether a real and true Infinite, in its proper and strict Sense, can be greater than another; the several Parts of Relative or Creaturely Infinites (so I call those that are generated by an uniform, convergent, or divergent Series, *vide Chap. 1. Part 2.*) may have finite Proportions to one another, but true Infinite must be One only, to which nothing else can be equal. *Space* is infinite, as being the Place (to speak so) of the *Divine Ubiquity*, and having some Connexion with the true, sole and proper Infinite; but Matter, if it be infinite, must either be so by the Necessity of its own Nature, or by the Will of the *Creator*. Not by the Necessity of its own Nature, because then it must be every where; which being already demon-

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monstrated false, it's impossible it should be infinite by the Necessity of its own Nature: For if it be true, that Matter is not every where, it is possible it might be no where; that is, it's possible it should not be at all; and consequently, it is impossible it should be infinite by the Necessity of its own Nature. Not by the Will of the *Creator*; for then a Creature might be equal to its *Creator*, since the justest Image we can form to our selves of the *Creator*, is Perfection, apply'd to absolute Infinitude; and if absolute Infinitude could be apply'd to a Creature, then no doubt Perfection might be also; so that then an infinitely perfect Creature might be possible, that is there might be two or more infinitely Perfects, which is a Contradiction. Besides, could Matter be infinite, being of those kinds of Infinites that have three Dimensions; by the *Analogy* and Simplicity constantly observ'd by Nature in like Cases, it must be similar, and equal to the other actual Infinite, to wit, *Space*. Lastly, Matter is limited, in its own Nature capable of actual Limitations and Divisions, and seems properly design'd for the Limits of *Space*, which is, in its own Nature, unlimited; and consequently, Matter seems not at all design'd to be infinite in its Extent. Now if Matter be not actually infinite, in a proper Sense, since *Space* is so, and since the *fix'd Stars* are limited in their Bulks and Sizes, it

is impossible they should be infinite in their Number; for when the Sum is finite, and each single Part or Division of the Sum is finite, the Sum of the whole of such Parts cannot be infinite. It is true, we can assign no Reason for a limited finite Number of *fix'd Stars*, and it is not impossible, but that their Number may be as great as Created finite Matter can amount to, since all the Works of God are immense, and worthy of Him who is Omnipotent. But still they cannot amount to real and proper infinity in Number, since Matter seems not capable, in its own Nature, to be infinite, but design'd for the Bounds and Limits of infinite *Space*, and the Conveniency of the material grosser part of *animated* Beings, who seem not to be infinite in their Number. Now if the *fix'd Stars* be finite in their Number, or the material part of this Universe limited in its extent, the Bodies at the Limits of the material part being quite free from *Attractions* upon the side toward the infinite *Space*, must yield to the *attracting* Force of the Bodies toward the *common Center of Gravity* of the material part, and the *Boundaries* yielding, the Bodies next them must do so likewise, and so on even to the Center; for nothing but an equal *Attraction* on all Hands can keep the *fix'd Stars* constant in their Places, and nothing but an infinite Number rang'd up and down the infinite *Space* can be sufficient for this; where-

wherefore since it has been evidently demonstrated, that the material part of this Universe is finite in its extent, if the World had lasted from all *Eternity*, the whole Matter of this Universe had been long before this time amass'd in the *common Center of Gravity*, and had there made a lifeless Heap; which not having happen'd, it's plain this World has not lasted from all *Eternity*, nor can of it self continue to all *Eternity*. And it's not unlikely that the vast, if not immense Distances of the *fix'd Stars* from us and one another, has been design'd to retard this Effect, as long as the Designs of Providence may require.

§ XI. In the former part of this Chapter, I have demonstrated the impossibility of the *Mechanical* Production of *Animals* and *Vegetables*; and I shall have occasion in the following Chapter to make it evident, that every generated *Animal* is produc'd from a pre-existent *Animalcul* of the same *Species*, and that every *Vegetable* arises from a small Plant of the same kind. And it is impossible it can be otherwise, upon our Adversary's *Scheme* of admitting nothing but Matter and Motion; for if *Animals* and *Vegetables* cannot be produc'd from these (and I have clearly prov'd they cannot) they must of necessity have been from all *Eternity*; and consequently, that all the *Animals* and *Vegetables* that have existed, or shall exist, have actually been all included in the first of every *Species*:

*cies*: Or, which is the same thing, that pitch'd upon any one *individual* of either kind, now existent, that all the *Animals* or *Vegetables* that proceed from it, were included in it; and it, with all these, was included in that one from which it proceeded, and so on infinitely backwards; and consequently, since there is no new Production, all that are, or ever have been of that *Species*, were once actually together included in one infinitely remote from this now pitch'd upon; and that any finitely or infinitely distant time (if they have so long existed) from their Generation or Production, all the *Animals* included in the first of every *Species* were there moving and living *Animalculs*, and all *Vegetables* included in the first of every Kind, were there actually growing and increasing small Plants. Now since every *Animal* and *Vegetable* has been prov'd to consist of *Organs* in Number infinite (tho' if the *Organs* of *Animals* be only finite in Number, it will as effectually serve our present purpose) it is absolutely impossible, any of the *Species* of *Animals* or *Vegetables* should have existed from all *Eternity*; for then their Number must have been infinitely many, and the *Animalculs* and small Plants, being *Organical* Bodies, and consisting of Parts, and those infinitely many too, and being all included in the first of every *Species*, or those infinitely distant from the present *Individuals*; these first ones of every *Species* must  
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of necessity have been infinitely big, for infinitely many *Organical* Bodies, how small soever, amass'd together in one Body, must make that Body infinitely big. It's true, that tho' an *Animal* or *Plant* consists of an infinite Number of *Organical* Parts, yet their Sum, or the *Animal* or *Plant* is but of a finite Magnitude, either because the last *Organs* are infinitely small (as they really seem to be) or that infinite here is only meant in a general, or less rigorous Sense, for indefinite, or so many that we cannot distinctly conceive their Number, or give a Reason for their Limits: But seeing these *Animalculs*, or *Seed-Plants*, in this Case must be finite, as consisting of Parts, tho' infinitely small, yet infinitely many in the first Supposition, and of a finite Number of finite Parts in the second Supposition; consequently, had the World lasted from all *Eternity*, the first of every *Species* must have been infinitely big: So that unless we could admit the first of every *Species* of *Animals* and *Vegetables* to be infinitely big (and how absurd such an *Hypothesis* is, I leave the Reader to judge) it is absolutely impossible, that *Animals* and *Vegetables* should have been from all *Eternity*; neither can I see how this Argument can be evaded, if we admit all *Animals* and *Vegetables* to proceed from pre-existent small *Individuals* of the same *Species*, included in the first of each kind. And it is impossible this can be otherwise, upon our  
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Adversaries Scheme, if the *Mechanical* Production of these be impossible, which I think I have clearly demonstrated.

§ XII. Had the World lasted from *all Eternity* as it now is, it is altogether impossible, but that *Arts* and *Sciences* must have been brought to a far greater Perfection than they have as yet attain'd. Let us take, for Instance, the *Mathematicks*: It is certain this Science has been more improv'd within these two hundred Years, than in all the time past before that, since we have any Records; and two or three hundred Years more, going on at the rate of those last past, may carry 'em to a height which we cannot now imagin. Now it is altogether impossible the Improvements already made should be lost, seeing they contain things so absolutely necessary to the *Accommodations* of Mankind; they will as soon forget the use of Houses and Cloaths, as the Advantages to be reap'd from this Science; wherefore, had the World *Eternally* been, this Science had been brought to its utmost Perfection long 'ere now. It may be alledg'd, that *Inundations*, *Deluges*, *Wars* and *Pestilences* might have destroy'd all the former Improvements, and then we should have been left to begin anew. As for *Deluges*, it is impossible they should have been Universal, *i. e.* Naturally and Mechanically impossible; for the only *Philosophical* Account of an *Universal Deluge* hitherto assign'd, *viz.* that of Mr. *Whiston's*,

ston's, depends intirely upon the Principles of *Gravitation*, which have been prov'd not to be *Mechanical*, in the Sense us'd by our Adversaries; and since there could be no *Universal Deluge* naturally, (and to allow a Principle above Nature, or the establish'd Laws of *Mechanism*, is to yield the Cause) particular Inundations could never have been sufficient to have obliterated the remains of Sciences, particularly of this one, which by Inscriptions on *Medals*, by the Ruins of *Architecture*, by *Pillars*, *Instruments*, and *Machins*, might have been preserved in despite of every thing but an *Universal Conflagration*. Besides, it's meerly precarious, to say there have been *Deluges* that have done any considerable Damage to the whole Rational Creation, and may be deny'd with the same Reason it is affirm'd, since it is certain we have heard of none of any considerable Consequence. It's true, there happen'd an *Universal Deluge* in *Noah's Days*; but besides, as I formerly said, that this was not brought about naturally, we know not, if this and the other Sciences had arriv'd at any great Perfection before this *Deluge* happen'd. So that we are not certain, if the Perfection of *Arts* and *Sciences* has been much retarded upon this account. Wars and Pestilences, it's true, have been and may be, but those do not happen universally over the whole World at the same time; and there are always some  
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Countries and many particular Persons who escape; so that it's impossible these things could have obliterated all the Remains of *Arts* and *Sciences*. I believe it almost impossible by any means, except *Annihilation*, or a general Conflagration, so to deface the Memory and Remains of all our modern Improvements, that some of 'em should not last at least ten thousand Years to come; and yet its certain we have no evident Footsteps of Improvements older than three or four thousand Years. In short, this Argument holds good against every thing but *Universal Deluges*; and to admit or suppose any such to have been, is to yield the Cause, since its impossible to explain such by the Laws of *Mechanism*, or to account for them by Matter and Motion as things are now settled; and to quit these, or to allow any thing to have happen'd contrary to 'em, is to admit *Powers* superior to them, which, for ought we know, might have produc'd that which they can now so powerfully alter. And tho' *Arts* and *Sciences* may have been at a stand for many Ages in some Countries, yet that is nothing to the whole Globe. For since that Principle which prompts some Men to improve *Arts* or *Sciences* they are inclin'd to, springs naturally in their Minds, according to the *Scheme* of our Adversaries, and is neither imprinted upon them, nor were the things themselves reveal'd to them by any superior

perior Beings; this Principle, in an infinity of Ages, without any *Universal Deluge*, or even any particular one of any great extent, must of Necessity have brought *Arts and Sciences*, and the other Accommodations of Life, to a much greater Perfection than we see they have now attain'd. From all which, duly weigh'd, it's plain this World has not *Eternally* been as it is now. And indeed, the Accounts of our Improvements answer very well to the time assign'd by *Moses* for the Creation of the World.

§ XIII. If the Number of any *generated* thing, which we behold on this Globe, does either increase or diminish continually, in any finite Number of Years how great soever, by any finite Number how small soever, then this World could not have been from all *Eternity*, in the present state we now behold it. For had it increas'd in any finite Number of Years how great soever, by any Number how small soever, long before this time their Number had been infinite; so that this poor *Mole-Hill* of a *Globe* had not been able to contain 'em: And had they decreas'd, their Number had been none at all, *i. e.* the whole Race had been extinguished. But since neither of these has happen'd, it's plain the present state of things has not been for ever. It's not easie to believe, for instance, that the Race of Mankind has been *ebbing* and *flowing*, without

considerable increases or diminutions, from all *Eternity*. We are certain *Wars, Pestilences and Diseases*, and the other means of Destruction, have not been fewer for these 300 Years by-past, than ever they been since we have had Records; and yet it's plain, the Number of Mankind has considerably increas'd in that time. Sir *William Petty*, from Observations on Births and Burials has discover'd, that in 360 Years the Mass of Mankind is doubled in these Countries. Had they thus increas'd from all *Eternity* in other Countries, all the *Planets* within our *System* had not been able to have contain'd them by this time; yea, if in many *millions* of Years they had but increas'd by an Unity continually, their Number had been infinite by this time. But it's plain, both the Number of Mankind, and that of other *Animals* and *Vegetables*, must have perpetually increas'd, if the World has been from all *Eternity* as it is at present. And since their Number is but finite at present, it's evident, this World has not been for ever as it now is. And indeed the present Number of Animals does answer very well to the common *Æra* of the Creation. These two last Arguments I have subjoin'd, not as conclusive Proofs of the Production of this present Universe in time, but as concurring Confirmations of the former Arguments.

§ XIV. Lastly,

§ XIV. Lastly, How improbable is it, that this World should have been from all *Eternity*? Is there any thing we see in any part of it, or even in the whole, that has any other Quality suitable to that *Cardinal* one of Self-existence? We our selves are certainly the noblest part of this *System* we are acquainted with; and yet God knows how unfit any of us, or even our whole Race is, to have so extravagant a Compliment bestow'd upon us as *Self-existence*, when as we can scarce be said to be at all, so very a Nothing our Lives are in respect of *Infinite Duration*. We might, with as much Reason, imagin Mankind *Omniscient* or *Omnipotent* (which we know too well he is not) as *Self-existent*; these Qualities cannot be separated; where one is, all the rest must necessarily be; for whosoever is *Self-existent*, must necessarily and independently be. *Necessarily*, because depending only on himself alone for Being, he may be when and while he pleases: *Independently*, because his Being, and all that's necessary to it, depend on himself alone. By *Self-existence*, in its true and positive Sense, I mean not only the not having a Cause of Being, which is but a Negative Quality, and concludes nothing Positive: But by *Self-existence* here I mean *Self-origination* (if I may speak so) or a positive Quality in some Being, *analogous* to, or something of that Kind; as a Power to give a Being to another is. It is true,

true, we have no adequate *Ideas* of *Infinity*, *Self-existence*, *Creation*, and the like, and in their common Acceptation these are only Negative Qualities; but they must have Positive Meanings, or Ideas, answerable to them, and must in some one Being imply active and positive Qualities, in their proper and genuine Sense, tho' we finite Creatures can form no Images of them; and therefore the positive Quality imply'd by *Self-existence*, in its proper and eminent Sense, must imply Activity, Power and Knowledge: For *Self-existence* apply'd to an inanimate thing is a Contradiction, a self-existent Body is as impossible as a self-moving Body; for a thing to owe its Being only to it self, must imply more than meer Existence, it must necessarily involve Power, Activity and Knowledge. *Vide Chap. 2d. Part 2d.* And consequently, whoever necessarily and independently exists, must Be, in opposition of all others; and whoever is so, must be able to preserve his Being in despite of all other Powers, *i. e.* must be *Omnipotent*: Whoever is *Omnipotent*, must know all things that are possible to be done or let alone; for he can never be suppos'd to do that which he knows not how to do, *i. e.* must be *Omniscient*; and whoever is *Omnipotent* and *Omniscient*, all things else must depend on him; for being so, he may make all things depend of him, if already they did not so. Besides, other things must  
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depend of him for the very same Reason, *viz.* because he can make 'em do so. As also, whatever is *Omnipotent* and *Omniscient*, depending on nothing, and having all things depending on him, must be supremely good and wise; because he knows all things, can do all things, has no Reason nor Cause to determin him to any thing that's bad, since nothing can hurt him, nor any Power annoy him. So that it's very plain, that whoever is *self-existent* must possess all the other suitable *Qualifications*. And since we must of necessity admit something to be *self-existent*, how much more reasonable is it to believe, that that *immense Being*, which possesses all other *Qualities* suitable to that of *Self-Existence*, has been from all *Eternity*; and when it was his Pleasure, has created this noble Representation of himself, *viz.* This beautiful State of things, which bears so visible *Characters* of his infinite Power and Wisdom, as shall abundantly be shewn hereafter. And this is the *third Opinion* about the *Origination* of the Universe, which must of necessity be true, since after the other two, which I have (I think) abundantly confuted, this is the only possible remaining Choice.

## C H A P. V.

## Of the Existence of a Deity.

§ I. **T**HAT there are no *Speculative Atheists*, to me seems as evident, as that no Body who has consider'd the Matter, can be absolutely convinc'd, that the three *Angles* of a *Triangle* are not equal to two *right ones*. The *Fool* indeed, may have said in his *Heart* there is no God, i. e. lewd and vicious Men may have heartily wish'd within themselves, that there were no secret Observer, nor that there might be any publick *Punishment* of their Crimes, because it's their Interest there should be neither: But that a Man of an ordinary Understanding, who has seriously set about the matter, and has duly weigh'd the Evidences for the *Being of a Deity*, should at last come to a full *Per'uation* of his *Non-Existence*, to me seems as impossible, as it is for one who has attentively read the first Book of *Euclid*, and rightly understood what he has read, to be convinc'd, that the Sum of the *Angles* of a *right lin'd Triangle*, can be more or less than two *right Angles*. It is true, most Men think  
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nothing of the matter, and few give themselves the trouble to enquire, whether there be a God or not; they think such idle *Speculations* become those only who know not how to live, and to make the best use of Life that may be. And of this kind of *Atheists* there is abundance in the World; for its certain we can never determin any thing about what we never or but very *slightly* think; and there are millions who live and die ignorant of many Self-evident Truths, because they never took the pains to consider them. But the being or not being of a Deity, is a Matter of that Moment to the Government of the World, the necessary Consequences thereof do so nearly concern the Happiness or Misery of every *individual rational Creature*, and the Objects that inculcate the Consideration of it are so many, so different, and so *conspicuous*, that none but the wilfully blind can withstand such convincing Testimonies. Now tho' the *Demonstration* of this great Truth, viz. that there is a *supreme Being*, who made and governs this present *System* of things, has employ'd the Care of many *wise* and *good* Men, so that none can doubt of it for want of sufficient Proofs, who will but give themselves leave to consider; yet since the *Evidences* for it can never be too many, and since some are to be wrought upon by one sort of Argument, others by another, I shall here set down those which agreed best with my manner of thinking

ing, which are founded on the *Principles* of a juster *Philosophy*, and a more genuine Explication of Nature, than was known till of late. And I have chosen this way of Reasoning, the rather because our modern *Atheists* have taken *Sanctuary* within the Bounds of *Natural Philosophy*.

§ II. All the Arguments of the *preceeding Chapter*, are so many Proofs of the Existence of a *supreme Power*, who made and governs this present *System of things*. For since this World could neither be produc'd by the casual *Concourse* of *Atoms*, neither could have been from all *Eternity* it self, as it has been sufficiently prov'd; and since that it now is no body doubts, of *Necessity* therefore it must have been produc'd or created, some time or another, by some pre-existing Power. Now since there is nothing else in being but *this World*, unless we admit that *supreme Power* we are now speaking of; and since it could neither have been produc'd from the *fortuitous concourse* of *Atoms*, nor have been from all *Eternity* of it self; it must of necessity have been produced by that *supreme Power*, whose Being we now inquire into. Since then this *supreme Power*, of necessity must have created this beautiful *System* of things, and since existing independently, He must for ever be, and have been; therefore that *great Power* must necessarily now exist. All the Difficulty any rational

onal Creature can have about the Existence of a *Deity*, is how to conceive his having for ever been of himself without a Beginning. Now if we could avoid this Difficulty, by saying, that this *System* was produc'd by the casual meeting of *Atoms*, or by alledging it to have for ever been of it self, we might have some slight pretence for our *Infidelity*. But since this Difficulty does equally lie against all these three Suppositions (for if the World has been produc'd by the *casual concurrence of Atoms*, then a *Void*, *Atoms*, and *Motion*, have for ever been, without a Beginning, of themselves; if it has been from all *Eternity of it self*, as it is, then the Case is plain, that we must allow something to have been without a beginning of it self) wherefore I say, since the very same Difficulty equally and unavoidably urges all the three Suppositions; is it not more reasonable and *congruous* to allow that Being to have been for ever of it self, without a beginning, to whom we may ascribe, and who does necessarily possess all other suitable Perfections, rather than either of those others, which we know are neither endow'd with, nor capable of such eminent and transcendent Qualities? I will not say with *Des Cartes*, that because in our Conception of a Being *infinitely perfect*, there must be included *necessary Existence*, that therefore such a Being must of necessity *actually* exist. But sure I am, since our

main Difficulty in the Conception of the Existence of a Being *absolutely perfect*, is his necessary Existence, or his having for ever been of himself, without a beginning; it is much more reasonable to suppose that Being to have for ever been of himself, who necessarily possesses all other suitable Qualities, than those who neither possess, nor are capable of any of 'em.

§ III. The *Existence of Matter* is a plain *Demonstration of the Existence of a Deity*. I believe no body doubts, that there now exists a quantity of *solid Mass*, out of which the *celestial and terrestrial Bodies* were form'd; and tho' perhaps in our most solid Bodies there be more Pores than Parts, or more *Vacuity* than *Solidity*, yet there is still sufficient, not to permit us to doubt of the Existence of Matter. Wherefore since Matter now actually is, whence or how came it first to *be*? It could never have been of it self, since we are certain, that it is destitute of all *active Qualities* whatsoever. And *Self-Existence*, in its proper and positive *Idea*, seems to involve (besides having no Cause for the Being of the thing to which it is apply'd) some other active Qualities, as Power and Knowledge, as I have already hinted. But we have already prov'd, that Matter cannot move of *it self*, nor when put in motion can it rest of *it self*, nor of *it self* change its Course, nor alter its Direction; it can neither change its *Figure*, nor *Colour*, nor *Situation*; in a word, it is endu'd with no Property but Inactivity, which is a Negation. How absurd is it then,

to imagin it could have brought *it self* into Being, when it can do just nothing *of it self*? To conclude, could Matter be Self-existent, even in the Negative Sense of the Word, it must necessarily have been; and if necessarily, it must, from the Necessity of its Being, have been ever, and every where, that is, it must be Eternal and Infinite; from which, it's plain, that it must have been every where *Uniform*, all Variety of Forms being a Contradiction to Necessity; it must have also been immoveable, for had it necessarily mov'd in any one Direction, with a determin'd Velocity, by the same Necessity it must have mov'd in a different Direction with a different Velocity, which being impossible, it could not have mov'd at all; for both these are such Contradictions to Sense and Reason, as none but an *Atheist* can swallow. We may as reasonably imagin, that *Non-entity* should bring it self to become a positive Being, as conceive it possible, that Matter should, *of it self*, for ever have been. Besides, admitting Matter to have been for ever of it self, yet this will not solve half the Difficulties arising in the Formation and Production of the present State of things, as has been shewn in the *preceding Chapter*, and shall be now farther illustrated. Whereas the admitting of an *infinitely Powerful and Perfect Being* to have for ever been, and to have created the *solid Mass*, and out of it to have fram'd this wonderful *System* of Things, contracts all the Difficulties of Nature into this one of his *Existence*. For as to the Difficulties of Cre-

ation, they vanish quite before *infinite* Power; for Power implies a Capacity to act, and *infinite* Power a Capacity to act every thing not involving a Contradiction. Wherefore since Matter now actually is, and yet it neither could have been for ever of it self, nor had it for ever been, would that remove the Difficulties arising in the Formation of this present *System of things*, but, on the contrary, would multiply 'em: is it not much more reasonable then, to admit an infinitely wise Being to have been for ever of *himself*? Whereby all the Difficulties, in the conceiving the Manner of the Production of this *Universe*, do vanish at once.

§ IV. It has been formerly shewn, that this *Universe* was not form'd by the same Laws it is now govern'd, and which its several Parts in their Actions do now obey; and therefore, of necessity there must have been some Power superior to, and distinct from that of Matter, which form'd this *System* at first, and prescrib'd Laws for its Parts afterwards to observe. We see all the Changes that now happen in this material World, are according to the Laws established in the *first Chapter*. But this *System* of Things could never have been brought into its present Order, by the now establish'd Laws of Nature (even admitting Matter to have been *eternally existent of it self*) as I have abundantly shewn in the *first Chapter*; neither one, nor all of these Laws were sufficient to have separated that thin and rare fluid of *Light*, from the other grosser and more dense ones, and amass'd it in  
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the *Sun* and *fix'd Stars*; neither did the Laws of specifick Gravity obtain in the *Formation* and *Situation* of the inner Parts of our *Earth*, and the other *Planets*; nor in the *Separation* and *Situation* of the several Fluids thereof. By none of the known Laws of Motion was the *Number*, *Magnitudes*, or Distances of the *fix'd Stars* determin'd. the Figure, Number, Densities, Gravitations upon one another, Situations and Order of the *Planets* adjusted. the Number, Distances and Magnitudes of the *Satellites of Jupiter*, the Form and Bulk of the *Annulus of Saturn* limited. In a word, the whole process of the *Formation* of the *celestial* and *terrestrial* World, as to their principal Parts and Arrangements, could be brought about by none of the Laws of Motion and *Mechanism*, that now obtain in this settled state of things; or at most these Laws had but a small share in their Production. Wherefore since this beautiful *State of things* has not been for ever *of it self*, nor could be form'd by the Powers and Laws of Nature, it is plain it has been produc'd by something superior to Matter and its Qualities: and consequently, by that *supreme* Being, into whose *Existence* we are now inquiring. And truly, from what has been here said, and a great deal more of the same nature, alledg'd in the *first Chapter*, it is evident, we can have no Notion of the *Formation* of this present State of things, other than what we have of a *Planetary Clock*, or any other complicated *Machin*, form'd by the Hand of a skilful *Artist*; where tho' the Rules of Moti-

Motion, and Laws of Nature may obtain; when it is adjusted and finished: the Parts of the *Machin*, their Figures, Sizes and Proportions, and the connexion and fitting the whole, was brought about by voluntary Operations, different from, and sometimes contrary to the Law of Nature and Motion, whereby it now subsists a regular *Machin*, and performs its intended Operations; which, nevertheless, it is not of it self able to perpetuate, without frequent interposals of the same voluntary Powers, and the removal of those Obstructions and Disturbances, Time, and the frail Nature of material Organs must bring upon it. And tho' this, no doubt, be but an infinitely low and faint Resemblance of that *noble* and glorious Work, yet it is the best and most adequate our *Imaginations*, without running upon evident Contradictions, can frame.

§ V. As the Formation and Disposition of the *great Bodies* of this Universe, did necessarily require the Hand of a Being infinitely Powerful; so likewise did their first Movement, and impress'd Motions, demand the Impulse of an Almighty Hand to set them first a-going. For supposing the *celestial* Bodies already form'd, and rang'd according to their several Distances from one another: yet without this Impulse, they had continued unactive, unmoving Heaps of Matter. Now it has been already shewn, that no Particle of Matter, nor any *Combination* of Particles can move themselves, and therefore it was absolutely necessary, that something different

ferent from themselves should put them in a Motion, with a due Velocity, along the *Tangents* of their several *Orbits*; otherwise they had for ever continued in the Places, and at the Distances they were at first set. Wherefore since it is certain, that these *glorious Bodies* have been rolling about these four or five thousand Years; and since it hath been demonstrated, that they are not self-moving, being *solid Masses of Matter*; since it has likewise been shewn, that they have been set a-going by some powerful Hand; and what Hand sufficient for such a Work, but his who is Infinite, both in Strength and Skill? and consequently, he who did so *great and glorious Things* must necessarily be.

§ VI. Not only the *Formation*, and first *impulse* of the great Bodies of this Universe, along the *Tangents* of their *Orbits*, but their *Centripetal* impulses, whereby their *Revolutions*, or *orbicular Motions*, are perform'd, did, and still do, require a Power beyond that of Matter and the Laws of Nature, to the preservation of their Motion. Sir *Isaac Newton* has demonstrated, that to the Motion of any of the *Celestial Bodies* in an *Orbit*, there is necessarily required two Impulses, one along the *Tangent* of the *Orbit*, another toward the Center, about which the Body moves. The first being once impress'd, does continually persevere, and needs no more to be renew'd, as is evident from the first Law of Nature: The second continually draws the *celestial Body* from its *rectilinear* Motion, and forces it into a *curvilinear* Orbit, so that it must  
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be repeated every Minute of Time. Now these *secondary* Impulses arise from that *Universal Principle of Attraction*, whereby every Particle of Matter, and all the Bodies of this Universe tend toward one another; and by which the *Sun*, being the far greatest Body of this our *System*, draws toward him the *Planets*, and they their own *Satellites*, and without which they would for ever wander in right Lines. But it has been demonstrated in the *first Chapter*, that this Principle, whereby the *Revolutions* of these glorious Bodies are perform'd, is independent of the Laws of *Mechanism*, and only accidental (no ways *essential*) to Matter, but implanted therein by some extrinsick Power, and consequently (since it must be repeated every Minute) must be perpetuated in it by some uninterrupted Influence, or by the persevering *Energy* of the first Impression. And seeing there is nothing in Nature, but Matter, and the Powers thereof, unless we admit that supreme Being for whose Existence we contend; therefore the *Revolutions* of the *celestial* Bodies, in their several *Orbits*, do necessarily infer the Existence of a Deity.

§ VII. The *Existence* of *Animals* does necessarily infer the *Existence* of a *Deity*; for it has been demonstrated in the *former Chapter*, that all *Animals* are, in their own Natures, *perpetua mobilia*, that they have some Principle above the Power of Matter that governs their Motions; it has likewise been shewn, that every *individual Plant* and *Animal* is a *Machin* of an infinite number of *Organs*; that no *Animal* is or can be produc'd

duc'd or generated by the Force of Matter and Laws of *Mechanism* (that all *Animals* and *Vegetables* that ever were or shall be, were all created, or form'd at once, as shall be afterward shewn) and that all these are absolutely unaccountable from the Laws of Motion, and consequently, must spring from a Principle independent of, and altogether above the Powers and Properties of Matter. Now whenever we forsake the Powers of Matter, and the Laws of *Mechanism*, we necessarily must have Recourse to the *Existence* of some Power superior to, and independent of Matter, and all its Laws and Properties, and consequently, to that *infinitely Perfect Being*, into whose *Existence* we are now inquiring; since there is nothing besides Matter and its Properties in the World, unless we admit the *Existence* of that *supreme Being*.

§ VIII. The *spontaneous* Motions of *irrational*, and the voluntary Motions of *rational* Animals, the *Freedom of Will*, and liberty of chusing or refusing in the latter; and, in a word, all the *Appearances* of Nature, which are above the Powers of *Mechanism* (which are innumerable) are so many undeniable Proofs of the *Being* of a *God*. For since this present *System* of Things has not been from all *Eternity of it self*, and since these are allow'd to be above the Powers of *Mechanism*, they must have been produced by some Power Superior to those of *Mechanism*. But no Power is sufficient for those, but his *who alone does great and marvellous things*; who adjusted all the Parts of this noble *Fabrick* by Number, Weight

Weight and Measure, and therefore he that brought about all these glorious things, *He who alone does Wonders*, must necessarily be.

§ IX. The Preservation of the *Being* and *Faculties*, both of the animate and inanimate Part of this *System* of things, does necessarily require the Power, and consequently, the *Existence* of a Being absolutely perfect, *i. e.* of a Deity. For since this *System* of things has not been from all *Eternity* of it self, as we now behold it; and since there is no necessary Connexion between the being of any one Part thereof, or of its *Faculties*, this present Moment, and their being the next; and since we see both have been preserv'd for a considerable time: This Preservation of the *Being* and *Faculties* of things can never be accounted for, without having Recourse to an *Almighty* Power, which may be sufficient for all things not involving a Contradiction; and therefore that *Omnipotent* Being, endow'd with this Power, must necessarily be. It is true, Things (as they are now constituted by *infinite* Power and *Perfection*;) once brought into Being with such and such essential Qualities, may be suppos'd to persevere and continue in Being, and in Possession of their Qualities till some Cause destroy them, or alter their Natures; but, if we reflect upon the possible manner of their *now* Being, that is, the Preservation of their Being and Qualities, it can never be conceiv'd without having Recourse to an infinite Power. For either things now being, were for ever so: *That is*, were *self-existent*, that is, are necessarily existent, that,

is, are incapable of Motion or Variety of Forms as I have formerly shewn, which is a Contradiction. Or they were brought into Being by an infinite Power; *that is*, had an active energy impress'd on them, to persevere in their Being; *that is*, are continu'd in Being by Virtue of an original Impress from an Almighty Power; *that is*, owe neither their first Being, nor their Being now, to themselves nor their essential Natures, but to an Almighty Fiat, which both produced them into Being, and impress'd on them a Power or Virtue to continue their Being, which, if possible, being subtracted, they wou'd without any other Cause sink into their Primitive Nothing. Without all Peradventure, *the Works and Gifts of God are without Repentance*, they are all immortal and eternal in their Beings, and essential Natures, as partaking of his own Immortality, and being all of them, in a higher or lower Degree, *Images and Copies* of his Being and communicable Perfections; and tho' possibly he might have given them different Natures and Constitutions at first, from what they now have; yet being now constituted and form'd into such Beings, it may be doubted whether he can destroy the essential Natures of Things thus constituted, *annihilate* these he has made, or essentially alter their Natures, without counteracting himself; which seems a Contradiction in infinite Perfection. There is no Doubt, they may pass through infinite Varieties of *Forms and Modifications*; and this our *System*, or the *System* of the whole Universe, with all its Inhabitants, may  
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be changed into greatly different Shapes and Modifications; yet their essential and *general* Natures must be preserv'd and subsist for ever. Not by Virtue of their once being brought into *Existence*, which may be consider'd as a *Transient Act* that subsists no more, but by an active permanent Principle of *Immortality* (so to speak) which is communicated to them from the Divine Nature, as being his Images, and Emanations from him, whereby being once brought into Existence, they are enabled to continue in their Being and Natures. There is nothing more evident than that God cou'd create nothing but what shou'd be in a higher or lower Degree, an *Image* or *Copy* of his infinite Perfections. The Effect must have some Resemblance to the Cause, but this can never reach *Independence* or *Self-existence* in a proper and strict Sense, that were a plain Contradiction to *Creation* or being produc'd. So that Perseverance in Being in Creatures, cannot be the necessary Consequence of their Being, else being once produc'd, they wou'd necessarily continue in their Being, and become Independent for the Continuation of their Being, which is Inconsistent with the Nature of Creatures; but the continuance of their Being is, by a Virtue or *Energy*, deriv'd from the Divine Immortality, of which their being and persevering in Existence is a *Copy* and *Resemblance*; and as the Divine *Immortality* is not a dead inactive Principle, like a *vis inertiae*, so neither is the Copy thereof in Creatures, but

but a living active Principle, which once impress'd, preserves created Things in their Being and essential Qualities without the necessity of a continual Interposition. This may be more easily understood by comparing it with the Nature of *Attraction* or *Gravitation*, and with the Nature of Motion in Bodies. I think it pretty evident that *Attraction* is not essential to Matter as such: For were there an universal *Plenum*, or no vacuities in the amassed finite Quantity of Matter now being, and no Motion (neither of which imply a contradiction) then matter might be conceiv'd without Gravity, or at least, it's Gravity without effect, which in an active Principle, is much the same thing: And therefore it is highly probable that Gravity is a divine *Energy* impress'd on Matter. Of the same kind of Qualities, in Bodies, is Motion. And all the Motions in the Universe, not depending on *Attraction*, must have been originally impressed by a Cause different from Matter, since it has been demonstrated that Motion is not essential to Matter. Now it is plain Motion is an *active Principle*, which is continued by Virtue of the first *Impression* and is not essential to Bodies: After the same manner likewise may *Attraction* be conceived to be. And with due regard to the different kinds of Qualities, in a proper *Analogy*,

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logy, we may Reason concerning that Principle of self-preservation in all created things, whereby being once brought into Existence, they are enabled by virtue of the first *Energy* to preserve for ever their Being and essential Qualities. And universally we may reason thus in a proper *Analogy* about all the Copies, or *Images*, in the Creatures, of the particular Divine Attributes communicated to them, except *Self-existence* and *Independency*. They all, not being meerly *inertes potentia*, but Life and Activity being essential to them all, in a higher or lower degree. Now since this Principle of the *preservation* of their Being and Qualities, does not flow from the Nature of things when brought into Existence, (else they wou'd now being produc'd, exist necessarily) but supposes an *Energy* or active Principle communicated to them by which they continue to *be*; The Original of this communicated Principle, *the Great and Omnipotent Origin of all Being and Perfections* must necessarily *be*.

§ X. But that Argument for the *Existence* of a *Being infinitely perfect*, who made and governs this *System* of things, which of all others affects me most, is that it is altogether impossible, this Universe cou'd have been better contriv'd or more compleatly finished, than it is, had *infinite Wisdom* first actually design'd it, and then put the Design

Design in execution. Or which is the same, there are legible and indelible *Characters* of *infinite Wisdom*, in the *Contrivance* of the whole, and of the several Parts of this admirable Fabrick of the *Universe*; and it is altogether impossible for the united skill of Men and Angels, to mend any one Part, or to contrive it better, or even to find out any real Defect therein, due Regard being had to the universal Benefit of the whole *System*; and to the particular Natures and Dispositions of the Inhabitants of it's several Parts. For in the *Contrivance* and *Adjustment* of the several Parts of this noble *Machin*, where the Choice is various, and sometimes infinite, that one is pitch'd upon, which alone cou'd bring, the most advantages to the whole, or which only cou'd bring about the design'd Effect. This is a very large Subject, and to treat it according to it's Dignity requires far greater Abilities than I am Master of, and more Room, than the Limits I have prescrib'd to my self will admit. However, I shall endeavour to illustrate the same in the following Particulars. But first of all it will be convenient to lay down a general *Scheme* of this noble Structure.

§ XI. Let us then conceive the *Mundane Space*, or the universal Place of all Bodies, to be boundless in it's Extent, or

indefinite in it's Dimensions, and in it at vast Distances from one another, the fix'd Stars (huge luminous Bodies, like the Sun) to be plac'd: Keeping always the same Distances from one another, and moving only (perhaps) about their own *Axes*; about each of these let us imagine several Bodies like our *Planets*, rowling in several *Orbits* at several Distances; and about those lesser ones, *Analogous* to the *Satellites* of our *Planets*. Each of these fix'd Stars with their Circumambient *Planet-like Orbs*, constituting that which is call'd a *System* of the *Celestial* Bodies. And how many such there must be in the vast extent of Space, a naked Eye in a cloudless Night, may give us some faint *Glimpse*, but much more a good large *Telescope* directed towards that *Region* of the *Sky*, which is call'd the *milky way*. Our Numbers fall very short here, and our *Aritmetick* can scarce give us an *Idea* of the vast Quantity of *Systems* that adorn this *stupendous* Piece of *Architecture*; and yet no doubt their Number is finite, and they are all included in a bounded Extension; for Matter seems not capable in it's Nature of being infinitely propagated. Moreover, let us conceive the glorious Body of the Sun, fix'd in the Center of Gravity (or near it) of this our *System*, and in the common Center of Motion (or

(or *focus*) of all the *Planetary Orbits*. And then next to him *Mercury* shall make his *oval round*, but so near him, that we can rarely obtain a distinct View of him, he being swallow'd up almost in the Light of the *Sun*. Next to *Mercury*, is our beautiful Morning and Evening Star *Venus*: Next *Venus*, our *Earth*, with it's Attendant the *Moon*, perform their friendly Course, and measure out the Year. Beyond our *Earth* *Mars* singly and alone, revolves about the same Center; next to *Mars*, *Jupiter*, the largest of the *Planets*, with his four *Satellites* turn round in concert; and last of all, *Saturn* with his five Guards, and his surrounding *Annulus* or *Ring*, describes the remotest *Orbit*, and concludes our *System*.

§ XII. For the ease of the Reader, in going through the following Parts of this Discourse, I shall set down here the Numbers that represent the *Periods*, the *Diameters*, *Distances*, *Gravities*, and Quantities of Matter, in those of the *Celestial Bodies*, which have afforded any Grounds for determining the same, as Mr. *Whiston* has calculated most of them from the latest Observations, by Sir *Isaac Newton's* Rules.

*The Periodical Times of each Planet's Revolution about the Sun.*

		Y.	D.	H.	
Mercury	} Revolves about the Sun in the Space of	{	00	088	00
Venus			00	224	18
The Earth			00	365	06
Mars			01	315	00
Jupiter			13	000	00
Saturn.			30	000	00

*The middle Distances of the Planets from the Sun.*

Mercury	} Is distant from the Sun.	{	020952000	} Statute Miles each 5000 Paris Feet.
Venus			039096000	
The Earth			054000000	
Mars			082242000	
Jupiter			280582000	
Saturn.			51354000	

*The Quantity of Matter in, and the Gravity of such of the heavenly Bodies (as afford Means for the determining the same,) at the same distance from the Center of the Sun, is as follows,*

The Sun's	66690
Jupiter's	00060 $\frac{1}{2}$
Saturn's	00028 $\frac{1}{4}$
The Earth's	00001
The Moon's	00000 $\frac{1}{28}$

*The*

*The Diameters of the Sun and Planets.*

The Sun's	494100	} Statute Miles each 5000 Paris Feet.
Saturn's	043925	
Jupiter's	052522	
Mars's	002816	
The Earth's	008202	
The Moon's	002223	
Venus's	004941	
Mercury's	002717	}

*The Diameter of the Celestial Bodies in English Measures.*

	Diameter.	
The Sun	822138	} English Miles.
Mars	4875	
The Moon	2175	
Mercury	2748	
The Earth	7967	
Saturn	93451	
Jupiter	120653	

*The weight of Bodies on the Surface of the Sun and Planets.*

On the Surface of	}	The Sun	10000
		The Earth	01258 <sup>x</sup> / <sub>2</sub>
		Jupiter	00804 <sup>x</sup> / <sub>2</sub>
		The Moon	00630
		Saturn	00536
		O 4	The

*The Densities of the Celestial Bodies.*

The Moon's	700
The Earth's	387
The Sun's	100
Jupiter's	076
Saturn's	060

*The Periodical Times of the Satellits of Jupiter.*

1	2
1 d. 18 h. 28 $\frac{1}{2}$	3 d. 13 h. 17 $\frac{2}{3}$
3	4
7 d. 3 h. 59 $\frac{1}{4}$	16 d. 18 h. 5 $\frac{1}{4}$

*The Distances of the Satellits from the Center of Jupiter.*

<i>Flanked by the Eclipses of the Satel.</i>	1	2	3	4	Semidia- meters of Jupiter.
	5. 578	8. 876.	14. 159.	24. 903	
<i>From the Peri- odical Times.</i>	5. 578	8. 873.	14. 168.	24. 968	

*The Periodical Times of the Satellits of Saturn.*

1	2
1 d. 21 h. 18' 31".	2 d. 16 h. 41'. 27".
	4 d.

4 d. 13 h. <sup>3</sup>47'. 16".    15 d. 22 h. <sup>4</sup>41' 11".  
 79 d. 7 h. <sup>5</sup>53' 57".

*The Distances of the Satellits from the Center of Saturn.*

1 2 3 4 5 } Diameters of the Ring of  
 $\frac{2}{7}$   $1\frac{1}{4}$   $1\frac{1}{4}$   $3\frac{1}{2}$  12. } Saturn.

*The middle distance of the Earth and Planets compar'd with their Periodical Times.*

	h	♃	♄	♅	♆	♇
According to observation.	954198	522520	152350	100000	72398	38585.
According to the Periodical Terms	953806	520116	152399	100000	72333	38710.

*The Times of the Revolutions of the Sun and Planets about their Axes.*

The Sun in 25 Days    Jupiter in 10 hours  
 The Earth in 1 Day    Mars in 24 $\frac{2}{3}$  hours  
 The Moon in 29 Days    Venus in 23 hours.

§ XIII. What a beautiful Scene of things have we here? How simple, and yet how wonderful are the Works of Nature? Such like are all the Effects of infinite Wisdom, her Foundations are plain and simple, but her

her *superstructure*, various and wonderful. Her Causes few, her Effects innumerable. Her Course the easiest and shortest possible, and her Means the fewest that can possibly bring about her Ends. Let us but consult the Books of the old *Astronomers*, and we will then have sufficient Ground to admire the frugal Simplicity of Nature, in this neat compact *System*; we shall see there what sorry, perplex'd Work they made, with their *Cycles*, and *Epicycles*, their *carrying*, and *equating*, their *Concentrick* and *Excen-trick* Circles, their *Stations* and *Retrogradations*, their solid *Orbs*, and the perpetual Change of the *Axe* of Motion, in the celestial Appearances: Such a strange *ungeometrical* and contradictory *System* they made of the *Heavens*; whereas from these few plain and simple Positions, all the Appearances of the *Heavens*, are accounted for, with wonderful Consistency and Facility.

§ XIV. The *Sun* being a huge Body of *liquid Fire*, brought into fusion by the Force of his Heat, and thereby sending out *Oceans* of that thin, active Fluid, which is the *Medium* of Light, and the cause of all Heat, turns round his own *Axe*, from West to East in about twenty five Days; which arises from his first Being put into such a *Circumgyration*, after His having been seated in his Place. And there being little or  
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no Resistance in his Region to retard his Motion, it has continu'd ever since, and will do, 'till the *Consummation* of all things; by Virtue of that first impress'd *Gyration*, and the first Law of Nature. His Motion about his own *Axe*, has been discover'd by *Spots* on his Surface, and his Fluidity, from his lesser Density in respect of some of the solid *Planets*, (some solid Bodies being more dense than most Fluids are) his *Sphæricity*, and that all Bodies heated to such a Degree, as the *Sun* must necessarily be, must certainly be *vitrify'd*. That is most continue in a Fluid State as long as this violent Heat lasts. Besides, the Fountain being in reason to be suppos'd of the same Nature with the Streams, since the *Rays of Light* are most certainly a thin, rare, active Fluid: Much of the same kind, with due regard to the Circumstances, must the Light in the Body of the *Sun* be; the greatest difficulty is to conceive how this *Globe* of liquid Fire shou'd be able to project his Beams with such Velocity and Force, so as to be able to dissolve every thing almost. That which may contribute to help our Imagination here, is what may be daily seen at a *Smith's Forge*, when the Iron is so much heated, as to run into *Fusion*, it sends out copiously, on all Hands, Streams of *liquid Fire*: All *sulphurous* Bodies likewise

wise emit and issue out *liquid Flames*, or burning *Smoak*, which by reason of the greater Gravity of the *Circumambient Atmosphere* is forced upwards, but if there were no *Atmosphere*, these *Flames* wou'd be projected every way equally. Now as *Bodies* act upon *Light* by emitting, refracting, and reflecting it, so *Light* acts on *Bodies* in heating them, and putting their parts in a vibrating Motion wherein Heat consists. And when their parts are thus heated, or put in *Vibrations*, beyond a certain Degree, they emit *Light*, and Shine, and this emission is performed by the vibrating Motions of the Parts. So that supposing the *Sun* a great Body like our *Earth* vehemently heated, that is having it's Parts set into vehement *Vibrations*, these *Vibrations* of the parts of the *Earth* wou'd forceably project, and violently thrust forth, immense *Oceans* of this subtile Fluid on all Hands. So that as *Light* produces these *Vibrations* on the parts of *Bodies*, these *Vibrations* in *Bodies*, are the cause of this emission of *Light* on all Hands. Every single particle in *Bodies*, when put in this vehement vibrating Motion propelling in it's turn and return of *Vibration*, a *Cylinder* of *Light* equal to it's Section thro' it's Center, and the Sum of all the particles of the heated Body urging so many such *Cylinders* on all Hands as is the Number

ber of such vibrating Particles. The greater Quantity of Matter, and larger Dimensions of the *Sun* in respect of the *Planets*, makes him sufficient for all the Expenses of Light, he lays out upon them, whereby his Bulk and Heat is constantly diminishing, as also, for drawing all the rest of the *Planets* and their *Satellites* towards him; for as has been formerly insinuated, the Force of *Attraction* of one Body upon several others, at the same Distance, is as their *Masses*, or Quantities of Matter: Wherefore seeing the *Sun* contains a greater Quantity of Matter by very far, than any of the *Planets*, the *Sun* must necessarily draw the *Planets* with their *Satellites* to him; which wou'd have unavoidably come to pass, had not the *Planets* at the instant they were seated in their Places, receiv'd an impulse, which drove 'em along the *Tangents* of their *Orbits*; and had not these two Motions been so exactly *Counterpoised*, that neither of them shou'd over-power the other. These with the small Resistance they meet in their Courses, and the Force of the *Attraction* diminishing as the Squares of their Distances increase, has made 'em ever since revolve in their *Elliptick Orbits*, in one of whose *Foci* the *Sun* is situated: And what is here said of the Cause of the *Primary Planet's* Motions about the *Sun*, may be understood of the *secondary*

*dary Planet's* Motions, about the *Primary ones*. All the *Planets* revolve about the *Sun* in *Elliptick Orbits*, or such as are not very far different from them; as also most of 'em, turn round their own *Axes* from West to East; the *Earth* in Twenty Four Hours, about an *Axe*, which is inclin'd to the Plane of the *Ecliptick*  $66\frac{1}{2}$  Degrees: And in it's Motion about the *Sun*, this *Axe*, of the diurnal Rotation, observes always a *Parallelism* with it self, the Reason of which is evident, for if a *Sphere* move about an *Axe*, this *Axe* (there being no other Motion suppos'd in the *Sphere*) is immoveable, while in the mean time every Point in the *Sphere*, describes a Circle about this *Axe*, and therefore if a *Sphere* move either in a *curve*, or strait Line, and at the same time turn round it's *Axe*, the *Axe* shall always continue *parallel* to that Line it was first *parallel* to; for that Impression which perpetuates it's Rotation upon it's *Axe*, and the impulse along the *Tangent* of it's *Orbit*, are two distinct Motions, which never interfere, and so each of them must continue the same as if the other were not; so that every Body turning about it's *Axe*, and at the same time describing a Right or *Curve* Line, must of necessity retain it's *Axe parallel* to it self, if nothing else disturb it. *Jupiter* likewise, *Mars* and *Venus*, and our *Moon*,

*Moon*, do also turn round their *Axes*, from West to East, and would retain this *Parallelism*, if not disturb'd by *Foreign Violence*. The *Satellites of Jupiter* and *Saturn* do likewise turn round their *Axes*, as is evident from hence, that they, like our *Moon*, turn constantly the same Face or *Disk* toward their *primary Planets*; and it is not improbable, that the others in which we have not had the Occasion of observing the like, may also turn round their *Axes*; that in a Revolution about the *Sun*, they may in all their Parts oftner than once, enjoy his Light and Heat; for it is from this Rotation of our Earth upon it's *Axis*, that we have the *Vicissitudes* of Day and Night, and from the *Parallelism* of the *Axis* to it self, in the *Earth's* Revolution about the *Sun*, and it's being inclin'd to the Plane of the *Ecliptick*, come the beautiful *Seasons* of the Year, *Summer* and *Winter*, *Spring* and *Autumn*, which are of such comfort and use to it's Inhabitants. From the *Opacity* of the *Moon* and *Planets* and their *Satellites*, and the *Obliquity* of their Planes to the Plane of the *Ecliptick*, together with their diurnal and annual Motions; and some of 'em revolving in *Orbits*, within one another, their *Phases*, their appearing and disappearing, their total and partial *Eclipses* arise.

§ XV. Since their *Solidity* and *Opacity*, the *Similar* Nature of their *Orbits*, and their *Satellititious* Attendance, their *Revolutions* about the *Sun*, and their *Rotations* about their *Axes*, their *Gravitations* and mutual *Attractions*, the Proportion of their *Periods* to their *Distances* from the *Center* of *Motion*, the *equable* Description of *Area's* in equal *Times*. Since, I say, all these and many more particulars are exactly the same in our *Earth*, and the other *Planets* with their *Satellites*, it is not improbable that they may be alike in other things, and that they may have *Inhabitants* both rational and irrational, *Plants* and *Vegetables*, *Water* and *Fire* *analogous* to, tho' not of the very same *Nature* and *Constitution* with ours; and since our *fix'd Stars* are exactly of the same *Nature* with our *Sun*, as shall be afterwards made appear, it is very likely that they have *Planets*, and these *Planets* have *Satellites*, and these *Planets* and *Satellites* have *Inhabitants*, rational and irrational, *Plants* and *Vegetables*, *Water* and *Fire*, *analogous* to those in our *System*. On these *Suppositions*, which not only are not absurd or contradictory; but on the contrary highly probable, as shall be afterwards made appear more fully; what a noble and glorious *Fabrick* wou'd present it self to our *Imaginations*? How is it possible for any one

one who had this *Idea* of the *Universe*, to think it possible such a beautiful *System*, cou'd have been produc'd without infinite Wisdom? None but the wilful, or obstinate cou'd resist such a powerful Impression of divine Power and Wisdom. On the other Hand, how is it possible to conceive that, that immense Number of glorious and Sun-like Bodies of the *fixt Stars*, those *vast* and huge Bodies of some of the *Planets* (in respect of our *Earth*) with their noble *Attendance*, were made for no other use but to twinkle on us in Winter Evenings, and by their *Aspects* to forebode what little Changes of Weather, or other pitiful Accidents were to be expected below, or to be peep'd at by some poor paltry Fellows of Astronomers? Or can any body force himself to think, that all *Animals* and *Plants*, have been exhausted in furnishing out this poor Corner, while the other more glorious, great and noble Parts, are left destitute and bare? Certainly they must have a great Opinion of themselves, and of their own Habitation, who can think so poorly of the rest of the Universe. It is true, from the great Resemblance, and *Analogy*, between the *greater material World*, and the *lesser* one, of an *Animal Body*; and from this *Hypothesis*, of *new Worlds*, and *new Setts* of Living Creatures, it's bearing hard, upon the noble,

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ble, and glorious *Oeconomy*, of the Redemption of lapsed Creatures: By confining it, to a *dirty Mole-hill* of a single *Planet*, some pious and enlight'ned Persons, have taught that as in an *Animal Body*, the *Brain*, the *Heart*, the *Lungs*, the *Liver*, the *Guts*, the *Spleen*, and all the *infinite Number* of *Conglobat* and *Conglomerat Glands*, had their several distinct uses, for purifying, refining, and exalting, the necessary Juices and *Spirits*, or for secerning, and throwing off, the noxious ones; and yet all this Complex and *infinite* variety of noble and wonderfully contriv'd *Organs*, were design'd solely, for the preservation of one *Animal* and the propagation of it's kind. So in the *greater material World*. All that *infinite* variety of *Stars*, and *Planets*, might be for purifying and subtilising, concocting and preparing the *Astral Influences* necessary for the *Preservation*, *Propagation* and *comfortable Support* of the several *Setts* of Creatures Inhabiting this spoil'd, defaced, and ruinous *Globe* of the *Earth*. Whatever may be in this I shall proceed in supposing, the *Planets* to be Inhabited, and that the *fix'd Stars* have their *Planets* and Inhabitants, yet they are not of the same Nature and Constitution with those of our *Globe*, as is evident from the different Degrees of Heat and Light they enjoy; as also from the different Vicissitudes  
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of their Day and Night, and the Seasons of their Year. *Mercury* is three times nearer the *Sun*, than we, and consequently enjoys nine times as much Heat and Light, he never removing Twenty Eight Degrees from the vast Body of Light. *Venus* enjoys twice as much Heat and Light, and her Motion about her *Axe* is perform'd in Twenty Three Hours, and so her Day is but one Hour less than ours; she has all the *Phases* of our *Moon*, appearing sometimes horn'd sometimes halv'd. *Mars* has no Inclination in the *Axe* of his Rotation to the Plane of his *Orbit*, and consequently enjoys a perpetual *Equinox*, but no vicissitudes of Seasons; he receives but the third Part of our Light and Heat. *Jupiter* likewise enjoys a perpetual *Equinox*, and and a Day of Ten Hours, but receives only the Twenty Fifth Part of our Heat, and *Saturn* but the Hundredth.

§ XVI. The *Satellites* of the several *Planets* suffer many and various Disturbances in their Motions from the *Sun*, as also, the Primary *planets* suffer likewise from the Forces of the *Sun*, and of the secondary *Planets*. Thus the *Moon* (if acted upon only by the attractive Force of the *Earth*) wou'd by a *Ray* from the Center of the *Earth*, describe equal *Area's* in equal times, wou'd about the *Earth* in one of it's *Foci*,

describe a perfect *Ellipse* of the same *Species* constantly, whose Plane wou'd be immoveable, or always the same, and whose Inclination to the Plane of the *Ecliptick* wou'd never vary; but by the Action of the *Sun* upon the *Moon*, all these Effects are disturb'd, for she neither describes equal *Area's* in equal Times by a *Ray* from the Center of the Earth, but somewhat larger ones in her *Conjunctions* and *Oppositions* with the Sun than in her *Quadratures*. Neither is her *Orbit* always *specifically* the same, nor is the *Earth* in any of the *Foci* of her *Orbits*; for they are more *Curve* about the *Quadratures*, and less toward her *Conjunctions* and *Oppositions*: In every Revolution she describes a new kind of *Curve*, and both the Situation of the Plane of her *Orbit*, and it's Inclination to the Plane of the *Ecliptick*, varies every Moment, and all these Uncertainties and Aberrations, are multiply'd by her nearer or remoter Distances from the *Sun*, besides a great many other Irregularities too tedious here to relate. Upon the account of all which, it has been so very hard for *Astronomers*, to reduce her Motions to Rule, and to express 'em in Numbers; and yet all these Irregularities are wonderfully accounted for, from the Action of the *Sun* and *Earth* upon her, upon the common Supposition of the Law  
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of Attraction, ev'n to a Nicety, beyond which Observation cannot distinguish, as is evident from Sir *Isaac Newton's Theory* of the *Moon*, which is a surprizing Confirmation of the Truth of that Principle. On the other hand, the Force of the *Sun*, but especially of the *Moon*, disturbs the Motion of the *Earth*, as is evident from our *Tides*, which do so exactly follow the Motions of the *Moon*, that he who knows the former, with some few collateral Circumstances, cannot be ignorant of the latter; for when the *Moon* comes to the vertical Point of any Place, we have a *Tide* there, as also on the Place *diametrically* opposite to it; this *Tide* is greater at the *Conjunctions* and *Oppositions* of the *Moon* to the *Sun*, than at her *Quadratures*, and greatest of all at the *Equinoxes*, especially if the *Moon* is then in her *Perigeum*, the Reasons of all which I have suggested in *the second Chapter*. And what is here said of the *Earth*, with respect to the *Moon*, may be with due Limitations understood, of any *primary Planet*, in respect of it's *Satellites*.

§ XVII. That the *fix'd Stars* are Bodies like our *Sun*, all the late *Astronomers* agree, for it's plain they shine by their own Light, since it is altogether impossible, that the Light of the *Sun*, shou'd be sent to them, and transmitted to us, so as

to make them appear so lucid as we see them. We see how faintly in respect of some of the *fix'd Stars*, *Saturn* shines for all his Bulk; and yet his distance is but a Point in respect of the nearest *fix'd Star*, from the *Sun*. The Rays of the *Sun* wou'd be so dissipated before they reach'd so remote an Object, that the best Eye of the World, cou'd not by it, discover them. Their Distance is so great, that the best *Telescope*, instead of magnifying 'em above what they appear to the naked Eye (as they do any Object, remov'd by any measurable Distance, how great soever) does considerably lessen them, so that they appear like lucid Points. Besides, tho' we in this Globe, approach nearer them some twenty four Thousand *Diameters* of the Earth, (or 188304000 Miles, allowing five thousand Feet to the Mile) one time of the Year than another, yet their *Parallax* is scarce sensible, if any at all, which cou'd not be, if they were at my moderate Distance: By Mr. *Hugen's* Computation, the Distance of the *Sun* from us, is to the Distance of the nearest *fix'd Stars* from us, as 1 to 27664, that is (allowing the Distance of the *Sun* from us to be 12000 *Diameters* of the Earth, and a *Diameter* to be of 7846 Miles, according to the best Calculations) the Distance of the nearest *fix'd Star* from us,

us, is at least 2404520928000 Miles, which a Cannon Bullet moving with the Velocity it has, when parted from the Muzzle of the Piece, wou'd spend almost seven hundred thousand Years to go through. Since then, both these are true, that they shine by their own Light, and that they are at such an immense Distance from us, it is plain, they must be *Bodies* like our *Sun*; which wou'd be evident, cou'd they be brought near us, or we near them, for it is only the Distance that creates our doubt. Now this being true, it is impossible they shou'd be all in the Surface of the same *Sphere*, since our *Sun* which is one of 'em, cannot be reduc'd to this Rule. Besides, their different Magnitudes, shew that they are at as immense Distances from one another, as the nearest of 'em is from us. Let us but imagine our selves remov'd at an equal Distance from the *Sun*, and *fix'd Stars*, we should then certainly perceive no difference between them; for as to all the *Planets*, that we see now attend the *Sun*, we shou'd not have the least Glimpse of them; both because their Light wou'd be too weak to affect us, and because all their Orbs wou'd be united, in that one lucid point of the *Sun*. In this Station, we shou'd have no occasion to imagine any Difference between one *Star* and another, but shou'd certainly conclude

both *Sun* and *fix'd Stars* of the same Nature; and knowing the Nature of one, we shou'd certainly conclude the same of all the rest, *viz.* that if one was a lucid Globe of liquid Fire, so wou'd all the rest be, and that they were at immense Distances from one another. If Mr. *Derham's* Conjecture, about the appearing and disappearing Stars (of which there are many Instances observ'd by *Astronomers*) be true, to wit, that they are *Planets*, belonging to some of the nearest *fix'd Stars*; which become visible, when they are in that part of their *Orbit*, next to our *Earth*, and disappear when they remove, to that part of their *Orbit*, which is farthest from us. I say were this conjecture certain, as it is not improbable, then we had a certain confirmation of the modern *Theory* of the *Celestial Bodies*; but I am afraid if the *fix'd Stars* actually had *Planets*, and they *Satellites*, that at our Distance we cou'd hardly see either. Since then there are several probable Arguments, (some of which I hinted before) that they have Attendant *Planets*, and no possible one to evict the contrary, we may safely conclude that the *fix'd Stars* are so many *Suns* in the Center of a *System* of *Planets* and their *Satellites*.

§ XVIII. Besides these already mentioned, there is another *Species* of Heavenly Bodies, call'd

call'd *Comets*, which revolve about the *Sun*; in very Oblong *Elliptick Orbits*, approaching to *Parabolick Curves*. The Times of their *Periodical* Revolutions are very long, since in three or four Thousand Years, we have not positively determin'd the Returns of above one or two; however, it's certain, that like our *Planets*, they do move in a recurring *Orbit*, that the *Sun* is in one of the *Foci* of this *Orbit*, that by a Ray from the *Sun*, they describe equal *Area's* in equal Times, that the same *Law of Gravitation* obtains in them, which does in the *Planets*; that their *Periodical* Times are certain and invariable, and that their Motions are regular, only their Course in their *Orbits* is not determin'd one way, but indifferently some of 'em move one way, others another: They are also about the same Bulk with the *Planets*, generally speaking; and like them are compact solid Bodies, but surrounded with a vastly large thin Fluid, intermixt with several grosser Particles, and composing an irregular unequally dispos'd, and uncertainly agitated Mass; which is call'd it's *Atmosphere*, whose *Diameter*, is ten or fifteen times as long as that of it's Body. Besides which, it has a long lucid *Train*, which is rais'd in it's approach to the *Sun*, by the heat thereof, and extends sometimes to four hundred Thousand Miles above it's Body.

dy. It is always opposite to the *Sun*, because it is the thinner part of it's *Atmosphere*, extremely rarified by his Rays; and so rare that the *Stars* may be seen through it. This *Tail* accompanies it through it's Course over all the *Planetary Regions*, encreasing in it's Approach to the *Sun*, and lessening in it's Recess. And which is very observable, as the *Tails* decrease, the *Atmosphere* is enlarged, which happens in their *Recess* from the *Sun*, and as the *Tails* encrease, the *Atmosphere* lessens, which happens in their *Access* to the *Sun*, just as it shou'd be according to this *Theory*. These *Comets* sometimes come so near the *Sun*, as to be heated to such a Degree that they cannot become cool again, in many Thousands of Years. Their *Tails* are broader at their *top*, than near the Body of the *Comet*; because in these almost void Spaces the Vapours are more and more rarified and dilated: And by this perpetual Rarefaction and Dilation, these Vapours of the *Tails* of *Comets*, are spread and dispersed through our whole *System*: And so are attracted by the *Gravitation* of the *Planets*, and mixt with their *Atmosphere*: As has been formerly shown; and become a supply of that continual decrease of Fluids, in the *Planets*, which is caused by the continual Consumption on Vegetation, and the  
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Putrification of these Fluids. And as among the *Planets*, they are the least, which revolve in least *Orbits* and nearest the *Sun*: So it's not unlikely these *Comets*, which in their *Aphelia*, come nearest the *Sun*, are of the lesser sort: That by their *Attractions*, they may not disturb the *Sun* too much. It is not improbable, that some of these *Comets*, have visited our *planetary Regions* oftner than once. The *Comet* that appeared in 1667, and that in 1682 had both, by computation, pretty near the same *Orbit*, the same *Aphelia*, and *Perihelia*, and the same Inclination of the *Plane*, of their *Orbits* to the *Plane* of the *Ecliptick*: And consequently, it's not improbable, that they were both one and the same *Comet*. And therefore the time of it's Revolution, is about 75 Years. The rest of the *Comets*, take up a longer time, in their Revolutions; and ascend higher from our *System*. Besides the *Comets* by reason of their great Number, the great distance of their *Aphelia*, from the *Sun*, and consequently their long stay and slow Motion in these *Aphelia*; must disturb one another, by their mutual *Gravitations*: And therefore their *Eccentricities*, and the times of their Revolutions, must sometimes be encreased and sometimes lessened: And consequently, it is not to be expected they shou'd constantly return in the same *Orbits*,  
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and in the same *Periodical* times exactly: It's enough, the changes be not greater than may be expected from such Causes; and from hence we may observe, the reason why the *Comets* are not contain'd in the *Zodiac*, as the *Planets* are: But direct their Courses differently, on all Hands, and through all the Regions of the Heavens; and that is, that in their *Aphelia*, where they move the slowest, they may be at the greatest distances from one another: And so attract and disturb one another the least that may be. The *Comet* that appeared in 1680, approached the *Sun* nearer than a sixth part of his *Diameter*, and by reason of that *Comets* great Velocity, at so near a distance, and the somewhat Density of the *Sun's Atmosphere*. It must have suffered some resistance to it's Motion thereby, and so must have been somewhat retarded, and must have approach'd somewhat nearer the *Sun*, so that in every Revolution, approaching nearer and nearer the *Sun*, this *Comet* must at last drop into the *Sun's* Body; as also this *Comet* may in his *Aphelium*, where he moves the slowest, be retarded by the *Attraction* of other *Comets*; and thereby in his return, be swallow'd up of the *Sun*. After the same manner, the *fix'd Stars*, which by little and little expire in Light and Vapours and so are extinguished, may be re-kindled

kindled by *Comets* falling into them, and being recruited by this new Fuel be accounted *new Stars*. If they be not *Planets*, accompanying the nearest *fix'd Stars*, as Mr. *Derham* conjectures.

§ XIX. Thus I have given a short View of this *System* of things, as it is at present, and I am of Opinion it is nearer the Truth than the *antient Theories*. And now let any one seriously reflect upon the *Vastness*, *Magnificence*, *Beauty*, *Order*, and *Symmetry* of this *Scheme*, and try if he can think it the Effect of Chance, or, if he can so much as doubt, that some infinitely wise and powerful *Architect* has rear'd this noble *Fabrick*. But to drive the Argument farther, let us enquire a little into the particular and obvious *Designs* and *Contrivances* of this *Divine Architecture*. And 1. It is plain from what has been shewn, that the universal Principle of *Attraction* or *Gravitation* obtains in all the Great Bodies of this Universe; and that the Motions of all the *Planets*, their *Satellites* and the *Comets*, are govern'd by one Condition thereof, *viz.* that the Force thereof at different distances from the Center of Attraction, is *reciprocally* as the *Squares* of these Distances. Now is it at all probable that so *universal a Law*, so powerful a *Principle*, and so constant a Rule shou'd be owing to Chance? If one with 10000 Dice, shou'd

shou'd throw 5000 Sizes, once or twice, or even 1000 Sizes once and again, we might possibly say he did it by Chance; but if with an almost infinite Number of Dice, he shou'd always without failing throw the same side in 'em all, we shou'd certainly conclude, he either did it by *Art* and *Contrivance*, or that these Dice cou'd turn up on no other side. Now I have demonstrated that *Gravitation* is not *essential* to Matter, and so it might have been without it; and yet all the Bodies of the Universe, so far as we can discover, are endow'd with this Principle; and observe this one Condition of it, and therefore, both were design'd by him who laid the Foundations of the World. 2. It is worth our Observation to take Notice, how constant and beautiful a Proportion, the Times of the Revolutions of all the *Planets*, and their *Satellites*, keep to their *middle Distances*; for universally, in all the Revolutions of the *Planets* about the *Sun*, and of the secondary *Planets* about the *primary* ones, the *periodical Times* is in a *Sesquialter* Proportion to the *middle Distances*; or the *Cubes* of the *middle Distances*, from the Center of their Motions, are in all of them (*Planets* and *Satellites*) as the *Squares* of the *periodical Revolutions*. 3. All the *Planets* and *Comets* by Rays from the *Sun*, and all the  
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the *Satellites*, by Rays from their primary *Planets*, describe equal *Area's* in equal Times, *i. e.* the *Area's* describ'd, are always *proportional* to the Times pretty nearly. So that when they approach to the Center of their Motion, they move faster, and when they recede from it, slower; so as to compensate their nearness, by their Swiftnes, and their Distance by their Slowness: Always making up equal *Area's* in equal Times. These two so *universal*, and so *regular* Affections, of the Motions of the *Celestial* Bodies, are not only discoverable by Observation, but are the necessary Effect, of the Law of Gravitation, just now mentioned to be the *Principle* of the Heavenly Motions. Can any Body now, who considers how many things are concurring to, and depending upon these beautiful *Proportions*, and regular Effects, so much as once question whether they are the Product of infinite Wisdom? Certainly nothing less cou'd be sufficient, to make the *Computation*, adjust the *Forces*, and determine the *Powers*, necessary towards the Production, of such exact and regular *Effects*. 4. All the *Planets* are so wisely situated, in respect of the *Sun*, that the denser *Planet*, is still nearest him, and the less Dense, is farthest remov'd from him; and the least Dense of all, is the most remote. Now can any Body think this was

was so ordered without *Design*? No certainly, it is so obvious no Body can miss of it; for it is plain the more Dense Matter requires a greater Degree of Heat, to fit it for natural Productions; and the less Dense, needs only a lesser Degree of Heat, for the same End. And consequently, their Distances were adjusted for this very Reason; and this by the by, is a Presumption for the *Planets* being inhabited, since according to their Densities, they are fitted with Degrees of Heat necessary for natural Productions: Now this Adjustment and these natural Productions were useless, if there were no Creatures to enjoy the Benefit of 'em; and we all know Nature has done nothing in vain. And therefore since these *Accommodations* are provided for living Creatures, there are such probably to enjoy 'em. 5. The *Velocity* of the *Planets* Motions, is so adjusted in respect of the *Sun*, and the *Velocity* of the *Satellites*, in respect of their *primary Planets*, that the *Planet* which is nearest the *Sun*, moves fastest, and those more remote, less fast, and the farthest, slowest of all. And so in the *Satellites*; the nearest to the *primary Planets*, moves quickest, and the remotest, slowest. For since the *Centripetal Forces*, are *reciprocally*, as the *Squares* of the *Distances* from the Center, and the *Celerities*

*lerities* in that case, reciprocally, as the *square Roots* of the Distances from the Center; and since the square Root of the remoter Distance is greater, than the square Root of the nearer, therefore the Velocity of the nearer, is greater than that of the remoter. Now this is a wise *Contrivance* of the *Author of Nature*; for since the nearer *Planet* enjoys more of the Heat of the *Sun*, than the remoter, it was fit the *Vicissitudes* of the *Seasons*, shou'd be quicker, that answering best the *Ends* of natural Productions; for since their Distances are least, and their Velocities greatest, that are next the *Sun*, their *Periods* must be shortest; and since they all move about their *Axes*, most, if not all of them, making thereby some *Angle* or other with the Plane of their *Orbit*, they must admit of variety of *Seasons*; and where the Heat is greatest, there for the conveniency of natural Production, it was necessary the *Seasons* shou'd be shortest, where the Heat is least, there the *Seasons* shou'd be longest: Now all these *Effects* are taken care of by this adjusting of the Velocity to the Distance. And what is here said of the *Seasons* in respect of the *Planets*, may be understood of the *Satellites* Influences, from their *primary Planets*; for whatever *Effects* the *primary Planets* produce on the *secondary* ones, it is doubtless most

convenient, the Vicissitudes thereof shou'd be quickest, in the nearest, and slowest in the remotest *Satellites*. And this, as well as the former, is a shrew'd Presumption of the *Planets* being inhabited; for all this beautiful Contrivance is lost, if there be no Inhabitant in the *Celestial* Bodies to enjoy the Benefit of it. 6. All the *Planets*, describe about the *Sun* in one of their *Foci*, *Elliptick* *Orbits* of one Species or another; and all the *Satellites* describe about their *primary* *Planets* in one of their *Foci*, *Elliptick* *Orbits* also; and the Planes of all the *Orbits* do very nearly coincide with one another, and with the Plane of the *Ecliptick*. That the *Planets* describe *Elliptick* *Orbits* about the *Sun*, there is no manner of doubt now among *Astronomers*. And tho' they say, that the *Orbits* of the *Satellites* are not exactly *Elliptical*, yet that is from necessary Causes, and is not owing to Chance, but to the already establish'd Laws of the Universe; yet still their *Orbits* are nearer *Ellipses* than any other *Geometrical* *Curves*, and may be reduc'd to these; and that the Planes of the *Orbits* of the *Planets* coincide with the Plane of the *Ecliptick*, and with one another nearly, is matter of Observation. Now is it imaginable, this beautiful and constant Order of these three things, of *Elliptick* *Orbits*, the Situation of the *Sun*

in the one of the *Foci*, and the Coincidence of the Planes, of the *Orbits*, with that of the *Ecliptick*, cou'd have been the Effect of Chance and Casualty? Or that it was without Design or Counsel? No certainly, for the Advantages thereby arising to our *Earth* in particular, are evident; for thereby, the colder and more Northern Places of our Globe, are brought some hundreds of thousand Miles, nearer the *Sun* in Winter than in Summer; which cannot but be of some small use to those Places, that by the natural Course of the Earth, are depriv'd of the benign Influence of the *Sun* at that Season. Now this Benefit wou'd be constant if the Place of the *Perihelium* did not change; but since that is not constant, the other is not durable, but temporary; But this change is not now to be taken notice of, since it is a Question if these Irregularities were any part of the first Contrivance of this Universe. Now tho' in the rest of the *Planets*, the Situation of their *Perihelia*, is not the same; yet nothing is to be concluded from thence, against this Argument, since we know not the Nature of their Inhabitants, nor of their natural Productions: But this we may conclude, since it is of notable Use to one of the *Planets*, it cannot be amiss to any of 'em, they agreeing in most things: But what-

ever be the Design thereof, yet the constant Order of these things are a sufficient Proof that they were not Casual, but the Work of infinite Wisdom. 7. The *Sun*, all the *Planets*, and their *Satellites*, so far as we have had occasion to know, move about their own *Axes*, the *Axe* of this Rotation is always *parallel* to itself, and they revolve all one way from West to East, and that in Planes, almost coincident with one another, and that of the *Ecliptick*. As to the *Rotation* about their own *Axe*, it is matter of Observation in the *Sun*, the *Earth*, *Mars*, *Jupiter*, *Venus*, the *Moon*, and it is very probable in the other two; and as to the *Parallelism* of the *Axe* of their Rotation, it is demonstrable *à priori*, as I have formerly shewn, and wou'd be nicely exact, if the same were not disturb'd by some collateral Causes; as also the Coincidence of the Planes of this Rotation, with one another, and with the Plane of the *Ecliptick*, is so very near the Truth, that the small Difference from it, is not to be regarded. Now can these constant and regular Effects be ascrib'd to any thing, but an over-ruling Providence? Can Jumble, and Confusion produce regular and invariable Effects? It is altogether impossible, and therefore, nothing but the Author of Light, and Order, and Beauty, cou'd have brought about  
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so uniform, and such constant Effects. Farther, let us now consider, that all these beautiful and comely *Proportions*, all these constant and immutable *Effects*, all these uniform and regular *Appearances*, which agree, not to a few things, or in some particulars, but in most of them, to all the *Planets*, to all their *Satellites*, to the *Sun*, and the *Moon*, and the *Comets*, and in a Word, to every thing in this our *System*, might have been varied, several and diverse ways; and yet none of 'em wou'd have fitted so well, to the present state of things, and the universal Benefit of the whole *System*, as these already settled. Thus there might have been an *infinity* of different, possible *Laws of Gravitation*, yet none of them wou'd have fitted our present *Circumstances*, so well as the *Reciprocal Duplicat*. There are innumerable *proportions*, besides the *Sesquialter*, yet none of 'em had suited us so well, because this is the Effect of the Law of Gravitation, and on these two, all the subsequent Advantages from the present establish'd *Motions of the Planets* depending, any other different from these wou'd have depriv'd us of those Advantages. The various possible Distances of the *Planets* from the *Sun*, the possible Times of their *Revolutions*, their possible *Celerities*, the possible *Figures* of their *Orbits*, and of the *Inclinations* of their

Planes to one another, and to the Plane of the *Ecliptick*, their possible *Densities* and *Bulks*, and the possible *Changes* of their many other *Affections*, are in number infinite; and yet I have shewn that most of these as they are at present, bring very considerable Advantages with them, to the *System* in general, which consequently wou'd be lost, were they dispos'd after another manner. Add to these, that all these *Affections* of the *Heavenly Bodies*, might have been in no regular Order, nor constant Proportion, at all, and consequently the possible Varieties of the *Celestial Bodies* might have been infinite among themselves, and different from those now mentioned. But seeing every thing is adjusted by *Number*, *Weight*, and *Measure*, seeing they observe *Order* and *Proportion*, and that every one of 'em is dispos'd in the fittest *Order*, the present state of things will admit, since both the whole and the several Parts of the *Celestial Fabrick*, is both very good, useful, and convenient, who that considers all these things, dares so much as doubt whether he who did all these things *lives and reigns for ever and ever*? Or who can forbear to admire and adore him, who *weigh'd the Mountains in Scales, and the Hills in a Balance, who stretch'd the Heavens like a Curtain, and held the Earth in his Hands, whose right hand,*

*band, and strong Arm does wonderful things  
past finding out.*

§ XX. Having now considered, some of the more general Affections, of the *Heavenly Bodies*, and of their Motions, and shewn some of the Advantages, arising from their present Order and Disposition. I come now to consider the *Celestial Bodies* a little more particularly, and first as to the *fix'd Stars*, can any thing beget a greater *Idea* of the Universe, or of it's Creator, than that *prodigious* number of glorious Bodies, like our *Sun*, rang'd all up and down the *immense Vast*, and remov'd at Distances from one another answerable to their Distance from us? This, not only their different *apparent Magnitudes*, but likewise the number of those of the first, and second Rate, does evince. For upon the Supposition, that every *fix'd Star*, is like our *Sun*, and governs in a Portion of *Mundan space*, equal to our *System*, then there must be only as many *fix'd Stars* of the first Magnitude, as there are *Systems* that can stand round ours; but there are but about twelve or thirteen *Spheres*, that can stand round a middle one, equal to 'em; and so many are the *Stars* of the first Magnitude. Again, if we examine how many *Spheres* can stand round this first Range of *Spheres* we will find their number betwixt forty eight and fifty two, and

so we find the number of the *Stars* of the second Magnitude. As for the several other Magnitudes, it is not altogether possible to determine their number, because they are not so distinguishable from those of the other Magnitudes, as the first and second are. Besides, I do not plead here for Accuracy, but only for things being nearly so; for, I do not think that the *fix'd Stars*, are either all of the same real Magnitude, or that their *Systems*, are all of the same Dimensions: These things being nearer any regular Proportion, than they are to Irregularity, is sufficient for my Purpose; for it is impossible for any Body, seriously to consider in his Mind, or view with his Eyes, what is certain about these glorious Bodies, to hinder himself from being ravish'd with the Power and Wisdom of the *Great God of Heaven and Earth*.

§ XXI. How *beautiful* and *glorious* a Body is the *Sun*, and of what absolute Necessity to the Being of all *Animals* and *Vegetables*! As to *Vegetables*, it is beyond all doubt, that without him they cou'd never rise above the Ground; for it is his Heat alone, that rarifies the fizy vegetable Juices about their tender Roots, and makes them force their way, to display all the Foldings of the slender Seed, and thereby to augment their Parts; just as we find his  
Heat,

Heat, raises the Liquor in the *Thermometrical* Tubes, and drives them through all it's winding Branches, and tho' perhaps *Animals*, might make a sorry Shift (supposing Food cou'd be supply'd 'em without his Influence) in a perpetual State of Darkness, yet it wou'd be a very miserable sort of Life, and cou'd be of no long continuance; for we know, how necessary the *Sun* is to purify our Air, and to exhale the *noxious* Dews, and the baleful Vapours of the Night; we feel a sensible Joy in his Light, and Heaviness in his Absence; foul Weather, and a cloudy Day, is a Disease alone, and he who understands the *Animal Oeconomy*, knows the Reasons, and the *Mechanical* Necessity of all these things, One thing ev'ry Body knows, *viz.* that by the Heat of the *Sun*, and the Action of his Rays, the Circulation is promoted and that infinite Number of the *excretory Ducts* of Perspiration, plac'd along all the superficial Parts of the Body are open'd, and enlarg'd, and so those Exhalations, which Nature has design'd shou'd be carry'd out of the Body, are more freely and plentifully deriv'd; which must needs give a greater Freedom to the Blood and Spirits, the contrary of all which, happens in the Absence of this *Benign Star*. But of this more afterwards. It's being situated immoveable in  
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the Center of our *System*, no Body who has been at the pains to consider the Matter, I believe doubts now, for not to mention at present the Controversy about the *Parallax* of some of the *fix'd Stars*, which Mr. *Flamsted* has observ'd, and whereby he pretends to demonstrate the Motion of the Earth, and consequently the Stability of the *Sun*; there are some other Arguments that will have sufficient Weight to settle the Matter among thoughtful Men. For 1. It is altogether impossible to account for the Appearances of the *Planets*, their *Satellites*, and of the *fix'd Stars*, in any tolerable manner, without admitting the Motion of the Earth. 2. It is likewise impossible to account for the Motions of the *Comets*, upon any other Supposition. And 3. that Analogy of the *Periodical Times*, to the *middle Distances*, which is the necessary Consequence of the establish'd Law of Gravitation, does demonstrate the Earth's Motion *a priori*; so that unless we wou'd subvert the whole *System of Astronomy*, and disprove the Causes of all the Celestial Motions, we shall never be able to prove the Stability of the *Earth*. For if the Celestial Bodies attract one another in a *duplicate Proportion reciprocally*, to their Distances from the Center of their Revolutions, then the *Earth* (and not the *Sun*) moves. Add to all these, that there

there is no tolerable Objection against the Earth's Motion, but has had a full Answer, and a plain Solution. Now what an Instance of Wisdom and Contrivance is this, in placing that Fountain of Light and Life, in the Center of his *System*. How unartful wou'd it have been, to have set him in a Corner, when he was to have giv'n Light and Warmth to all the Bodies round him; besides, to the conservation of any such Supposition (such as the *Tychonick* or *Ptolomiack*) there are requir'd so many different Laws of *Gravitation*, that any reasonable Person by inquiring into them, wou'd easily discover, that whatsoever was Matter of Fact, yet this Position of ours was the most simple and easy, and look'd most like the Effects of Wisdom and Design: For here one single Law, accounts for all the various Motions and Appearances of the *Celestial Bodies*. Thus then this great and glorious Body is fix'd, like a powerful and a kindly *Monarch* on his Throne, distributing Light, Warmth, and Life in plentiful Effusion, to all his surrounding *Vassals*, and that so equally, that the nearest have not too much, nor the remotest too little. These are such great, such wise Ends, as clearly speak the *Omnipotence* and *Omniscience* of their *Author*. Moreover, let us consider, with how much Artfulness his Bulk  
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and Situation, in respect of the *Planets*, is contriv'd, to have just Quantity enough of Matter to draw round him these Massy Bodies, and their *Satellites*, so various in their Bulks and Distances from him; and that in regular and uniform *Orbits*. How exactly his Body is rounded, how fully it has been saturated with the Fluid of Light, to be able to last so many Years without any sensible Diminution, tho' there are constant Emanations thereof upon his Attendants. As for his *Rotation* about his own *Axe*, it is no doubt likewise, for wise Ends and Purposes, perhaps it may be for the better propagating, and emitting this Fluid of Light, through the *Planetary Regions*, or for helping forward the *Revolutions* of the *Planets* in their *Orbits* round about him.

§ XXII. We can no otherwise gather the usefulness of the *secondary Planets*, to their *primary* ones, but by supposing the rest may reap *respectively*, some thing *analogous*, to the Benefits we of the Earth, receives from our *Moon*, which are 1. The supplying of the *Sun* in the Night time, for at least three fourths of the Year. Now how comfortable and delightful a thing this is, Travellers and Voyagers can best tell, *Curiosity*, *Ambition*, and *Luxury*, if not sometimes *Necessity*, have now made it unavoidable, that some part of Mankind shou'd be travel-

travelling by Land or Sea, in the Night Seasons; how pleasant then, and joyful a thing, is it to have a Light held us forth from *Heaven*, not only to guide our Steps, but to direct us in our Course, and to point out to us, how our time wears out? For a very little Experience, makes us reap both these last Advantages from the Presence and Motion of the *Moon*. 2. She raises our *Tides*, twice in twenty four Hours, which how absolutely necessary that is toward the subsistence of *Animals* and *Vegetables*, we shall now shew. Every Body knows that a *Lake* or *Lock*, that has no fresh Water running into it, will by the heat of a few Months, and it's Stagnation, turn into a stinking rotten *Puddle*, sending forth nauseous and poysonous Steams; for tho' I do not think, the constituent Particles of Water themselves, are alter'd by this Stagnation, yet no Water is absolutely pure, but contains a greater Quantity of Fleshy, Bony, Earthy, Salin, Metallick, and Vegetable Particles, than of pure *Element*; and it is upon these, the heat operates, by dissolving their Union, and combining them in new Forms, and separating these *Salin*, *Sulphurous*, and other *noxious* Particles which produce this Effect. Now tho' there be many thousands of fresh Water Rivers, daily running into the *Sea*, yet they are very  
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inconsiderable in respect of the *vast Ocean* of Salt Water, and wou'd by no means hinder it's Stagnation, and consequently it's Corruption and Stinking. But admit the Ocean once stagnated, and then the first Effect wou'd be, that all the Places toward the Shores, wou'd be first wrought upon by the Action of the *Sun*, and turn'd to a *Memphitis*, and then by Degrees it wou'd get farther, till the whole were become more *baneful* and *poysonous* than the *Lake of Sodom* and *Gomorrab*; whereby the *Fishes* wou'd be first destroy'd, and by the noxious Steams thence arising, afterwards the *Plants* and *Animals*; whereas by this Action of the *Moon*, the Waters are lifted up in a heap, as it were, and then let fall again; whereby the Waters near the Shores, are constantly secur'd from Stagnation and Corruption, and the beginning Malady stifled. This perpetual Change of new Water on the Shores, keeping any one Portion thereof, too short a time, expos'd to the heat of the *Sun*, to have it's mixture corrupted. Now what a *noble* Contrivance have we here! by appointing an *Attendant* to our *Earth*, all the *Vegetables* and *Animals* are preserv'd from certain Destruction; (but I am of opinion that to the full effect of this wise Design, the Salt of the Sea does very much contribute; for as I have said before, and may

may observe afterward, the pointed slender Particles of the *Salt*, stick the Parts of Bodies so together, that the Particles of Heat, cannot so easily tear 'em afunder, and it is *Fact*, and *Observation*, that there are many salin Rocks and Mountains dispersed over the Foundations, of the Great *Ocean*.) Besides this, how many Conveniencies for our *Navigation*, in Rivers and Harbours, does this ebbing and flowing of the *Sea* afford? No Body that considers them, can cease from Wonder, or can continue in Unbelief. And here perhaps it will not be amiss to consider, that if our *Earth* had any more than one *Moon* attending it, that we shou'd receive more Damage than Advantage from it; for tho' perhaps thereby our Light in the Night (provided she were of any Bulk, or at any Distance near to that of our present *Moon*) might be augmented, yet at the *Conjunctions* and *Oppositions* with one another, and with the *Sun*, we shou'd have Tides that wou'd raise the Waters over too much of our dry Land, and in their *Quadratures*, we shou'd have no Tide at all. In short, if our *Moon* were bigger or nearer the *Earth*, or if we had more than one, at any tolerable distance from us, we shou'd be every now and then, in hazard of being drown'd; and if our present *Moon* were less, or at a greater distance, or if there were none at all,

all, we shou'd be in hazard of being stifled by the noxious Steams arising from the *Ocean*, which wou'd stagnate more than it now does. From all which it's evident how wisely our *Satellit*, has been contriv'd for our Purposes. As for the numerous Attendants of *Jupiter* and *Saturn*, they must be reasonably expected to fit the Necessities of the Inhabitants of these *Planets*, since our Moon suits us so well. As to *Jupiter*, considering his Bulk and Distance from the *Sun*, being near 400 times bigger than our *Earth*, and receiving but a twenty fifth Part of our Heat: In what a dismal State of Cold and Darknes especially, wou'd he be in? Were it not for his *Moons* or *Satellites*, and for his Rotation about his *Axe*, in about *Ten Hours*: Whereby the little Vigor of his Light and Heat is compensated, by its quick Returns. His *Satellites* being each of them as big as our *Earth*, and reflecting in upon *Him* so strong, brisk, and vivid a Light, as they do: And their *Revolutions* being so adjusted, as may be seen, in the *Table of them in the beginning of this Chapter*: It thereby happens, that scarce any Part of this *Planet* is any time without the presence and influence of some one or more of these *friendly Attendants*. So that by this numerous Retinue, their strong Light, the encreasing *Periods* of their *Revolutions*, as they are distant

distant from him, and his quick Motion about his *Axe*: His Light and Heat are wonderfully encreas'd, from what they wou'd be without these Contrivances and Adjustments. But that which is the finest Contrivance of all, in these *Satellites* is (as Mr. *Derham* has observed,) in their Latitudes, or their Evagation towards *Jupiter's* Poles, the Latitude of the innermost being  $\frac{1}{3}$  of *Jupiter's* Diameter, of the next  $\frac{1}{2}$ , the third  $\frac{2}{3}$  and the last going beyond *Jupiter's* Poles, one third part of his Diameter: And as their Latitudes differ according to their Distances, and Periods, so they change their Latitudes in shorter or longer times according to their lesser or greater Latitudes, some making their Progress towards his Poles one way, whilst some are wandering the other, some staying there a longer time, and some a lesser and a lesser time, by which quadruple variety, those large Tracts towards the polar parts of this huge Planet, have a constant and yet various share in the Light and kindly Influences of these four Moons, and are scarce ever depriv'd of one or other of them. As to *Saturn* as he is yet farther from the *Sun*, than *Jupiter*, and has but the hundredth part of our Heat, he is accordingly provided with more *Satellites* (at least five if not more,) adjusted much after the same manner, and appointed for the

same ends and purposes with those of *Jupiter*, we have now describ'd. But he has still a further provision made for *him*, and that is his *Ring* the most surprizing and singular Appearance in all the *Celestial* Regions: It's size is prodigious, being more than twice as broad in *Diameter*, than *Saturn* is: And the breadth of the *Ring* it self about a fourth part of *Saturn's Diameter*: And it's distance from *his* Body about the same length, whereby the *Sun's* Heat and Light has a free admittance between the *Planet* and its *Ring*, while other Heat and Light is at the same time reflected in upon it, by this *Ring*. Its thickness is scarce perceivable, which prevents its throwing any great Shadow on *Saturn*. But its smoothness and reflecting faculty, is very considerable, as is evident from the exceeding Brightness and Illustration it reverberates on its *Planet*: So that it seems not unlikely, that it may be a kind of *specular* Contrivance, for reflecting Heat and Light on its central Sovereign, in his great distance from the source of Light and Heat. And very probably *Saturn's* Period, on his *Axe*, or diurnal Rotation, may be pretty quick, and his Inclination to the Plane of his *Ring*, or Plane of his *Orbit* pretty large, as it is in *Jupiter*, to make all these wise Provisions and Accommodation perfect and compleat. But further we may observe one very

very signal Instance of *Wisdom* and *Contrivance*, in placing the *Heavenly Bodies* at such a *Distance* from each other, and especially the greatest at the greatest *Distance*; for had they been situated much nearer to one another, they wou'd have caus'd prodigious Disorders in very different *Manners*, and in particular such destructive *Tides*, wherever there was any *Quantity* of *Fluids*, or great *Oceans*, that neither *Animals* nor *Vegetables* wou'd have been able to sustain their *Fury*; which by this prudent placing the *Heavenly Bodies*, at such a *Distance* from one another, are intirely prevented.

3. From our *Moon* the *Eclipses* call'd by her *Name* proceed, which is of exceeding use in *Navigation*; for by them the *Differences* of *Meridians*, and the *Longitudes* of *Places* are determin'd. Of the same use are the *Eclipses* of the *Sun*, and of the *Satellites* of the other *Planets*; which last being so frequent, are of wonderful Assistance, toward the *Solution* of this so desirable and so much desiderated *Problem*. And upon this *Head* of *Navigation* all *Astronomy* comes in, without which the other were meer groping in the *Dark*; but the *World* is already so sensible of the *Advantages* arising from the *Motions* and *Appearances* of the *Heavenly Bodies*, in the *Matter* of *Navigation*, that I shall insist no farther on this

*Topick*, neither shall I mention, the probable Influence the *Moon* has on *Vegetables*, *irrational* or *rational Animals*: The last having been fully canvass'd, in that *curious Treatise* of the *Accurate* and *Learned* Dr. *Mead* in his Book *de Imperio Solis & Luna in Corpora Humana*, but from this whole Section about the use of the *Attendants* of the *Planets* shall infer, that they are not mute Persons, in this great *Drama* of the World, but loudly proclaim the *Wisdom* and *Being* of their *Author*.

§ XXIII. As to the *Comets*, I have little more to say about them, than what I have already said, their *Natures*, *Orbits*, *Motions*, and *Situations*, have been so lately determin'd, (indeed it is but of late, that the *Astronomy* of the *Planets* themselves, and their *Satellites* has been brought to any tolerable Perfection, and much later since final Causes have been cultivated, with Care becoming so noble and useful a Part of *Philosophy*;) and there are so few accurate Observations about 'em extant, so few of 'em, that we know of, have visited us twice, that we have scarce any solid Foundation to build our Reasoning upon, all I think can be rely'd on is, that they are solid Bodies like our *Planets*, that like them they move in regular very oblong *Elliptick* Orbits, in one of whose Centers or *Foci* the *Sun* is placed.

placed. That they do revolve by the same Virtue of *Gravity*, and by the same Law thereof, as these do. That their *Train* is raised by the Heat of the *Sun* as they descend toward him in their *Perihelium*, seeing it encreases in it's descent towards the *Sun*, and lessens in its ascent from him. That this *Train* is only the more Fluid part of its *Atmosphere* extremely rarified. That some one or more have return'd in the same Orbits and with the other determining Circumstances, pretty nearly, whereby it is render'd probable that these were one and the same, only in different Revolutions. And if the uses assign'd to them by Sir *Isaac Newton* be real, as they are not improbable, to wit, the supplying the Deficiency and Expences of all the sorts of Fluids necessary or useful to our *System* in general, and to our *Globe* in particular. I mean not only Light and Heat to the *Sun* and *fix'd Stars*, Water and watery Vapours, to our *Atmosphere*, but the most subtile, most useful, and necessary part (towards Life and Vegetation) of our Air to that *Elastick Fluid*. And very probable, other Advantages *Analogous* to these they bring to our *Earth*, and suited to their particular Wants, to the other *Planets* and their *Satellites*. If, I say, these uses assign'd to them, and justly rising from their Natures, and the known *Analogy* of Things,

be real, then these wandring frightful Bodies may be justly concluded joyning in the *Chorus* and loudly resounding the same *Allelujab.*

§ XXIV. Come we now to enquire into the Wisdom of the Contrivance of the *Planets.* But having already shewn the *Analogy* between them and our *Earth*, and how probable it is that they are inhabited by Creatures fitted for such Habitations, I shall content my self with pointing out some of the most considerable Instances of *Design* and *Wisdom* in this our *Planet*; hoping the Reader will reason after the same manner (bating particular Circumstances) of the rest, and that, both because the design'd Brevity of this Treatise will not permit me to be so particular, as the Subject deserves, and because, if the *Analogy* hold in general, the particular ones (with allowance for Circumstances) will easily follow. And first let us consider the Advantages, arising to us by the *Rotation* of the *Earth* about its own *Axis.* We the Inhabitants of this Globe are so made, that once in sixteen or twenty Hours at most, we require a time for *Relaxation*, and generally speaking, in all healthful People this time is pretty equal, between six and nine Hours, the Store-houses of our Spirits will not permit any longer Application than twenty Hours, without In-  
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jury to our Constitutions, and much about the time of six Hours is requir'd to fill 'em again; and generally speaking, it is necessary that an Alternation of *Application* and *Relaxation*, shou'd be once in twenty four Hours. It's true Custom and Education, may get the better of these *natural Propensities*, and a very strong Constitution may bear out with harder Measures for some time; but the Young, and the Weak, and almost all at their own Liberty, naturally run into a *Relaxation*, and recruiting their Spirit by Sleep, once in twenty four Hours. It was likewise necessary, that the Air shou'd be at least cool and temperate, during the time of this Rest, for we generally find those that sleep in the open Air, or ev'n while the *Sun* is above the *Horizon*, the worse for it; the *Sun* and Heat exhaling the natural Perspirations too violently, while they are crude (hence it comes that People generally Sweat most who Sleep in the day time) and raising too quick a Motion, in the Blood, whereby the Sleep is less calm, and more disturb'd. And tho' we generally perspire more in the Night than the Day, yet the Perspiration is less crude, more natural, and less violent, and more according to the Necessities of our Constitution, in the Night than the Day. Besides, that of necessity, the Darknes is less subject to Noise

and Disturbance, than the Day. Now all these things are wonderfully provided for by the *Rotation* of the *Earth* about its *Axis*; for thereby we have the *Vicissitudes* of Day and Night, the Day for *Application* and spending our Spirits in about the necessities of Life, the Night by its Coldness and Quiet, to afford us time to recruit 'em, and lay up in store, for the Expences of the next Day; as also for nourishing the Muscles, Bones, Channels, and the other Parts of the Body; for the Business of Nutrition is mostly, if not altogether perform'd in the time of Rest, because the Blood has too rapid and quick a Motion, the Expences of the Spirits are too great, to afford Leisure, or Materials for nourishing the Parts in the time of Application: Besides that a gentle uniform Motion is requir'd to apply nourishing Parts, to the necessary Places, and to settle 'em there; and we generally find that People recovering from a Disease, and Children, sleep more, and are more fed by their Sleep, than by any other *Animal Function*, and gross People naturally Sleep longest. Likewise, what a comfortable and refreshing thing is the cool Breezes of the Night, the *Trade-winds*, to those that live under the *equatorial Parts*, without which Life wou'd be both exceeding short, and very grievous. As to these *Trade-winds*, they  
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are the necessary effect of the *Rotation* of the *Earth* about its *Axe*, which under the *Line* makes the Rays of the Sun direct and equal all the Year round, so that these parts being constantly under the *Sun's* Influence, his Heat rarifies one part of the Air, and the cooler and heavier part presses upon the hotter, and so makes a continual Wind in his Course from *East* to *West* under the *Tropicks*, which is both of great use in *Navigation*, and of great Comfort to the Inhabitants of that scorched Climate. Moreover, let us reflect upon the Necessities of our *Vegetables*, which are the support of Animals; we have before said, that the Heat of the *Sun* rarifies, and consequently raises the fizy vegetable Juices, at the Roots of the tender Seeds, and thereby forces the folded Branches to expand and enlarge. Now were the *Sun* constantly, or for any long time, shining upon them; these Juices wou'd not be at liberty to settle, and consolidate in the fit Places of the Branches; but wou'd be still rising higher and higher, till at last they burst the Canals, (if Vegetable Fluids were constantly supplied to them) and consequently cou'd produce nothing; whereas by this *Vicissitude* of Heat and Cold, what is rais'd in the Day-time, has time to settle and consolidate in the Night, and it's Cold runs the thin Juices

Juices first into thick, fizy, Substances, which the supervening Heat, by exhaling the watery Parts (which are now brought nearer the Surface of the *Plant*) does harden and fix. This we evidently see in *Nutgals*, and the other Excreescences of the Leaves of *Vegetables*; and generally, Countries that have moderately cool Nights, produce *Vegetables* of the firmest Union of Parts; and very hot Countries, suddenly bring up their Seeds, but their Parts are less firmly stuck together; they may be heavier, but not so tough or hard, tho' this too depends much upon the Constitution, and first make of the Seed. On the other Hand, had not the *Earth* mov'd upon its *Axe*, but only turn'd round the *Sun* in its *annual Period*, we had not only lost all these Advantages, which are so beneficial, if not absolutely necessary to the Being of our *Animals* and *Vegetables*, but we had suffered also such Inconveniencies, as neither of these cou'd possibly bear; for then, for very near one half of the Year we shou'd have been in perpetual Darknes, the Consequence of which wou'd have been, that first baleful and *sulphurous* Damps (by the Forces of the preceding Heat generated and rais'd,) wou'd have fall'n, which wou'd have stifled all the *Animals*, or had they surviv'd that, by Degrees, exceeding Rains wou'd have

have been pour'd down (as the Vapours became cooler) next Sleet, then Snow, and Ice, and Frost, which wou'd of necessity, not only have lock'd up all Fluids, but wou'd have freez'd the Blood and Spirits in the Channels, of all the *Animals* we are acquainted with; for as I have shewn before, there is a saline Body constantly swimming in our Air, which by the Presence and Action of the *Sun*, is so attenuated and reduc'd into so slender Particles, whose Points (being easiest broken) by the Force of the Fluid of Light are first beat off, as not to be able to do any Dammage: But in *his* Absence, they shoot themselves into oblong sharp Wedges, which stick together the Parts of all Bodies. Now in a half Years Absence of the *Sun*, in what Quantities, and with how much firmness wou'd these saline Bodies have form'd themselves! Certainly nothing that moves, whether *Animate* or *Inanimate*, wou'd have been able to support such a cold. And all this is not only demonstrable *a priori*, but is Matter of Fact, and actually happens in those Places that are under the *Poles*, during a much shorter Absence of this *glorious Star*. (Again, in the enlightned half of the Year, we shou'd have had, first huge Deluges of melted Waters, from the preceeding Snow, which likewise wou'd have produc'd suffocating

cating Mists; next all our Ground, wou'd have turn'd into a stiff stinking *Puddle*, (being in a manner dissolv'd by the Force and Quantity of the Snow Water) then wou'd *Sultry Heats* and a burning Air have scorched and chapp'd the Earth and gall'd the animal Tribes, that they shou'd have found rest, neither in Houses nor Dens; 'till at last the Heat encreasing without Abatement, the Blood and Spirits of all the *Animals* of our *Globe*, wou'd be quite exhal'd, or they turn'd delirous by the violent Agitation of the Blood and Spirits, and then dy'd in *Convulsions*, like so many Puppies in the *Dog-Days*; for it were absolutely impossible, that any thing that has Life shou'd resist such a Degree of Heat. It's true, there are some People live under the *Aequator*, yet they have but an uncomfortable time on't, tho' they are supply'd with constant Breezes and Trade-winds, arising from the *Earth's Rotation* about her *Axis*, and prodigious Quantities of Rain, falling by the Plenty of Vapours, rais'd by the Days Heat, and let fall by the supervening Cold of the Night, having as long a Night as they have a Day, which is a mighty Relief, the continued uninterrupted Action of *Sun*, being by much a far harder part, than the Degree of the Heat at stated Seasons. And as for the *Poles*, we have very certain Information, that few  
if

if any at all, inhabit near 'em. The extreme Degrees of Heat and Cold that happen there, being incompatible with an *Animal* Life. But that which makes the Case much worse than in any part of our *Globe*, upon this Supposition, is, that the Rays of the *Sun* wou'd be both direct, and there cou'd be no Rains nor Winds because it is the cooling of the Air, that is the cause of both; which by no means cou'd happen in our Case, every succeeding Hour heating the Air to a greater Degree than the former. Add to all these, that our Seas even notwithstanding our *Tides*, wou'd either be exhal'd, or turn'd into Desarts of Salt, and so, not only our Fishes wou'd be destroy'd, but we cou'd have no fresh Waters, seeing we cou'd have no cool Air to send them down: If we had any *plants* or *Vegetables*, they wou'd be but of one particular kind, *viz.* those which require the greatest Degrees of Heat, but it is demonstrable we shou'd have Occasion for none; for any Body who understands the *Animal Oeconomy*, will easily see that no *Animal*, such as we have on our *Globe* now, cou'd bear such an excessive and uninterrupted Degree of Heat. Upon all which Accounts it is very plain, that the present *Rotation* of the *Earth*, about her *Axe*, is one of the most

most signal Instances of Wisdom and Contrivance, that can be imagin'd.

§ XXV. Next let us combine this *Diurnal Rotation* of the *Earth*, about its own *Axe*, with the *Annual Revolution* of the same about the *Sun*, and the *Parallelism* of the *Axe*, of the *Diurnal Rotation* with it self: And from thence we shall have the beautiful Seasons of the Year; Seed time, and Harvest, Summer, and Winter; the comfortable Vicissitudes of colder and warmer Periods, of Snow, and Rain, Winds and Calms, of shorter Days, and longer Nights, and again of longer Days, and shorter Nights, and of all those delightful Changes, which are so Pleasant, Comfortable, yea, and Necessary in our present Circumstances. If the *Earth* had only turn'd about her own *Axe*, once in twenty four Hours, then all our *Vicissitudes* wou'd have been of Days, and Nights; which by no means wou'd have been sufficient for *Vegetation*. If the *Earth* had made a *Period*, about the *Sun*, once in the Year, without any *Rotation*, we shou'd have had but one long Day, and another equal Night; which as I have shewn, wou'd not have agreed, neither with Life, nor *Vegetation*. If both these had been united without the third of the *Parallelism* of the *Axe* of the *Diurnal Rotation* to it self, we might have had Days and Nights, but our  
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other Seasons wou'd have been uncertain, and in some Places none at all; and so the Effect of the annual Revolution wou'd have been destroy'd in some Measure. But by this wise Conjunction of all these three Modifications, we enjoy our Seasons, and the other consequent Changes of the Year, which are of so great use to us; for had we enjoy'd a constant uniform Season all the Year round, suppose of Summer Weather, then our Ground had been exhausted, and worn out by constant bringing forth of *Vegetables*, and wou'd have run into Weeds, and those other Plants that require the least rich Soil, and most Heat only; so that in a few Years the *Earth* wou'd have been reduc'd into a *Wilderness* of needless Herbs; for toward the Production of the more useful Plants, there is requir'd (besides a certain Degree of Heat and Moisture,) a *Lixivial Nitrous* or *Urinous Salt*, which keeps the Mould loose (for receiving the moist Air, and for the entry of that Heat and Moisture.) For tho' *Salts* consolidate Water, which consists of solid porous Parts, whereby their Particles are stuck together, yet they keep the Parts of Mould or Sandy Clay (which has little or no Water) asunder, and loose, by the same very Reason, for their Particles not allowing them entry into themselves, they get  
betwixt

betwixt 'em, and first separate their Union and then keep 'em from coming together; and perhaps both forward the Motion of the Liquors in the *Vegetable* Channels (which are certainly endow'd with some Degree of *Elasticity*, and capable of being stimulated, as is evident in younger Twigs and Branches, as well as *Animal* ones) and endows the Juices with the Qualities the *Plant* requires. Now these are either quite exhausted, or destroy'd, by constant Growth and *Vegetation*. We see the best Ground wears out in a few Years, and turns into wild useles Weeds; and all the Materials for enriching Ground, are gathered from Places, debarr'd from the Action of the *Sun*, and the Expences of *Vegetation*, but expos'd to the Air, and Weather, whereby they are impregnated with this *Nitrous* or other *Salts*: Such are old Turf, new Mould, the Dung, and Excrements of *Animals*, or those things which abound with *Lixivial Salts*; such are burnt Wood, burnt Turf, Stubble, and the like. Now all these, wou'd by a short Time's uninterrupted *Vegetation* have been quite spent. Add to these, that in a perpetual *Summer*, there wou'd not fall sufficient Quantities of Rain, to moisten and soften the Mould, to that degree that it is necessary for constant *Vegetation*; for we find there is twice or thrice as much Rain falls  
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in the *Winter* six Months, from *September* to *April*, than in the *Summer* six Months; and yet all this is but sufficient for one six Months *Vegetation*. Moreover, even the *Animals* themselves, cou'd not conveniently bear a perpetual *Summer*; for we find now, that the cold of the *Winter*, by stopping the Pores of the sensible Perspiration, keeps the Warmth more within, whereby there is a greater Quantity of Spirits generated, the Blood is less rarify'd, the natural Functions are more strong, and perform'd with more Vigour, the Digestion is better, the sensible Excretions more natural, and less violent, and the Crudities of the preceding *Summer* are settled and digested, I mean, in healthful and sound *Animals* (for the Case is quite otherwise in *Valetudinary ones*, as of necessity it must be) and in a moderate and not over tedious *Winter*; whereas in *Summer* the Blood is more rarify'd, the Spirits more exhausted, the *sensible Perspirations* more violent, and less natural, the Digestion worse, and all the Concoctions less thoroughly perform'd. So that it is evident we cou'd bear neither of these States perpetually, the Change of the *one* being absolutely necessary to qualify the Errors and Extreams of the *other*. If we had a perpetual *Summer*, we shou'd be reduc'd to meer *Skeletons*; if a perpetual *Winter*, we shou'd

turn Dull, unactive *Drones*. Now perhaps against all these it may be objected, that there are rational Creatures, who inhabit this *Globe* of ours, who are perpetually in both these Extreams, and yet are found to be not at all dispos'd, as I pretend they wou'd be. To this I answer, that tho' as to the Presence or Absence of the *Sun*, they may be much the same as I suppose, yet, there are other concurring Circumstances, which arise from the *Vicissitudes* of the Seasons in the other Parts of the *Globe*, which alters the Case quite; for there are constant Seasons of Rain, in the more *Southern* Countries, which fall for some considerable time, that both hinders the perpetual *Vegetation*, softens the Mould, and fattens it for the next Crop; there are Clouds of Snow, and Rain, impregnated with these *nitrous Salts*, which are driven (by the Force of the Winds) from colder into these hotter Countries; and there falling, do enrich the Ground. Besides that, even the Clouds, rais'd from these hotter Countries themselves, when distill'd into Rain, are sufficient for this end; for as I have said before, the Air every where is full of such *Salts*, as is known by Experiment. Let any one consult *Varenus*, and he will be satisfied that these Southern Countries have *Winters*, tho' not of Snow, yet what is abundantly sufficient

to stop the perpetual *Vegetation*, to moisten, soften, and fatten the Mould, and to cool the Blood, and other Fluids of the *Animals*. Now the Principal thing that makes this *Poetical* state of a Perpetual *Summer*, unfit for the present Constitution of the *Animals* and *Vegetables*, is, that in such a state (either arising from only a *Diurnal Rotation*, without an *Annual*, or an *Annual* without a *Diurnal*) there wou'd not be that variety of Rains, and cool Breezes, nor constant, and Trade-winds, nor overflowing Rivers, and such like Circumstances, which are the Effect of this Combining these two Motions together. I need not shew the Inconveniencies of a perpetual *Winter*, every Body is sufficiently sensible, that upon such a Supposition, we shou'd have neither *Vegetable* nor *Animal* in a very short Time; especially of any considerable use, or value, such as require a *Summer's* Heat, for their Growth; and as for *Spring* and *Autumn*, they are not so much distinct Seasons from the two former, as Gentle *Gradations* and easie Steps, whereby the one slides into the other, through the intermediate Degrees. From all which it is evident, how wisely these three so different Modifications, have been link'd together, for the Benefit of the Inhabitants of this *Globe*; for by these, we have sufficient Heat in *Summer*, to ripen

he Fruits that are the product of every respective *Climate*; and we are furnish'd with Reason, and made capable of Industry, to transfer the Products of one Country to another; we have Rain, and cooling Breezes in the *Winter*, of those Countries, where Heat is not wanting, to cool, soften and enrich the Mould, and to stop constant *Vegetation*; and we have Frost and Snow in others, where the Heat is not to spare, to lock up the Mould from being wash'd away, and to keep in either the natural, or adventitious Heats, 'till the time that all Circumstances concur, to have the product of the Ground brought to its *Vegetations*.

§ XXVI. Come we now to consider the *Obliquity* of the Plane of the *Ecliptick* to that of the *Aequator*, or of the *Axe* of the *Diurnal Rotation*, to the Plane of the *Annual Orbit* of the *Earth*, which makes an *Angle* of  $66\frac{1}{2}$  Degrees. I have already shewn, that if the *Equator* and *Ecliptick* had coincided, it wou'd have rendred the *Annual Revolution* of the *Earth* quite useless; for if the *Earth* had mov'd about its own *Axe*, and this *Axe* had been at right *Angles* with the Plane of the *Ecliptick*, the same Appearances as to the *Vicissitudes* of Day and Night, had happen'd, whether the *Earth* had mov'd round the *Sun*, or not; and the Alterations of Seasons, and all the Consequences

quences thereon depending, had not been at all; and what a hinderance this wou'd have been to *Life* and *Vegetation*, I have already shewn. Besides that in the *Torrid Zone*, the Heat wou'd have been intolerable, and not to have been endured; and in the *frigid Zones*, the Cold wou'd have destroy'd both *Animals* and *Vegetables*; and even in the *Temperate Climates*, the one half of 'em wou'd have made but a very comfortless Habitation, for such Creatures as we now are; so that but only the other half, wou'd have been any ways, a tolerable Seat for rational Creatures, and five Sixths at least of the whole Globe, wou'd have been rendered uselefs. But *God* who is wiser than *Man*, has contriv'd the Matter much better; for by this present *Obliquity* of the *Ecliptick* to the *Equator*, we reap one very considerable Advantage, which is taken notice of by my very learn'd and ingenious Friend *Dr. John Keill*, and that is, that we beyond the forty fifth Degree of *Latitude*, and who consequently have the greatest need of *Sun's* Heat, have more of it, take the whole Year about, than if the *Sun* had mov'd continually in the *Equator*; and they that live in the *Torrid Zone*, and the adjacent Places, even to the *Latitude* of forty five Degrees, who are rather too much exposed to the Heat of the *Sun*, than too

little, have by these Means, less of his Heat, than they wou'd have had, had the *Earth* observ'd a right Position. To these add, that since this *Globe* of ours, has been design'd for a Habitation of rational and irrational Creatures, of various *Temper*s, *Constitutions*, and *Dispositions*, and for *Vegetables* of different *Natures* and *Virtues*, requiring different Degrees of Heat, and Nourishment, to Ripen, and to bring 'em to Perfection, (to shew the *manifold* Wisdom of the *Author* of *Nature* in the Variety of every thing.) And since we find the present Heat of the *Torrid Zones*, very well fitted for all the kinds of *Animals* and *Vegetables* that inhabit and grow there, the Cold of the *Frigid Zones*, very tolerable to the *Inhabitants* and *Productions* of these Places, and the *Temper* of the intermediate ones, suited to theirs; those *Animals* that cannot transport themselves, and the *Vegetables* that require a greater Degree of Heat, not having too much, and the like *Animals* and *Vegetables*, that can suffer Cold, not having too little Heat, and the rational Creatures being endow'd with Reason and Means, to transport themselves where they live most at ease. And since it was impossible to have accommodated, all these so various and different *Animals* and *Vegetables* in a place of an equable and uniform, (or in one, and the

the same) *Climate*, it's evident that the present Situation of the *Axe* of the *Earth*, to the Plane of the *Ecliptick*, is the best (of that infinite Variety possible) that cou'd be, for our present Circumstances; for by any other very considerable *Alteration*, all or most of the mention'd Advantages would be lost. For all which Reasons we can never sufficiently admire the *Wisdom* of the *Author of Nature*, who has provided so liberally, and prudently for his Creatures.

§ XXVII. The same divine Wisdom, is conspicuous, in the Situation of the *Earth* in respect of the *Sun*; for had the Distance between the *Earth* and the *Sun*, been the same with the Distance between *Mercury* and the *Sun*, *i. e.* were we brought three times nearer the *Sun* than we are, or the *Sun* brought three times nearer us than he is, our Ground in Winter, wou'd have been hotter than red hot Iron, and what a Condition we shou'd have been in then, we may easily guess. On the other Hand, had the *Sun* been remov'd from us, or we from the *Sun*, to the Distance *Jupiter* or *Saturn* are remov'd, our hottest *Summers Day* had not afforded so much Heat, as those that now live under the very *Polar Star* (if any such there be) of our Globe, feel in the midst of Winter. Are not we then very wisely provided for, who are put in such Mediocri-

ty, between these two extreme Distances, that neither our Heat nor Cold is so violent; but that we may either endure 'em, or with a little Industry fence our selves against their Injuries? Again, as to the *Figure* of our *Earth*, we are certain from its *Shadow* in the *Eclipses* of the *Moon*, and a great many other experimental Observations that it is *Spherical*, *Spheroidal*, or *Orbicular*: Bating the inequalities the Mountains make, and this Figure is a wise and beneficial Contrivance, not only as it is the most Capacious, and renders all the parts of its Surface equidistant from its Center of Magnitude, and also from its Center of Gravity pretty nearly, whereby the equability of its *Rotation* about its *Axe*, and of its *Circumvolution* in its *Orbit* is preserv'd, and all the Motions on its Surface in all its Parts are rendered Uniform and Similar. But also, as the *Ingenious and Reverend Mr. Derham* has observed. 1. Because this Figure is the fittest of any for a regular and gradual Reception and Surrendry of Light and Heat, both these being admitted, and given of, by more slow, creeping, and insensible Degrees than they cou'd be were the *Earth* of a Figure made of plain sides or any other Figure whatsoever. 2. Because this Figure is the fittest for a regular and equal Distribution of the Waters, which being a hea-

vy Body, wou'd fall more unequally to-  
 wards some one side or other, were the  
*Earth* of a Figure made up of equal or  
 unequal Plains. 3. Because this Figure is  
 the most proper for an uniform and equal Di-  
 stribution of the Winds and the other Mo-  
 tions of our *Atmosphere*, for we find, that  
 large *Mountains*, *Bays*, *Capes*, and *Head-*  
*lands*, alter and disturb in some measure the  
 uniform Propagation of the Winds, even of  
 the general and constant *Trade-winds*, and  
 if the *Earth* were of a *Multiangular Figure*,  
 the advantages arising from regular Winds  
 and Fannings of the Air wou'd be disturb'd  
 and destroy'd to a much higher Degree.  
 Now these are some few of the Advanta-  
 ges of an *Orbicular Figure* in general, but  
 as to the prolate *Spheroidical Figure* in par-  
 ticular, tho' it be the necessary Result of  
 the *Earth's Rotation* about his own *Axe*,  
 and the Fluidity of its superficial Parts, at  
 the Commencement of this Rotation; yet  
 it also is very convenient for us. By the  
*Earth's* Motions about its *Axe*, the Parts en-  
 deavour to recede from the same *Axe* as  
 much as they possibly can, by a *centrifugal*  
*Force*, arising from the circular Motion; and  
 therefore, if the Matter of any of the Hea-  
 venly Bodies, was Fluid, at the Commence-  
 ment of this circular Motion, it wou'd ne-  
 cessarily have risen from the *Poles*, and ac-  
 cumulated

cumulated at the *Equator*, and so induced a *spheroidical* Figure on the *Planets* Body, generated by the *Circumvolution* of an *Ellipse* about its lesser *Diameter*. Now since it is evident to our sight, assisted with a good *Telescope*, particularly, in *Jupiter*, that the *Diameter* at the *Equator* is longer, than that at the *Poles*, and since *Sir Isaac Newton* has demonstrated that *Earth* is at least seventeen Miles higher at the *Equator* than at the *Poles*, and since many repeated *Experiments* on the lengths of *Pendulums* in different *Latitudes* have confirm'd the same, its plain that at the Commencement of the diurnal *Rotation*, the *Surface* of the *Planets* has been covered with a *Fluid*; which gives an Account why at every forty or fifty *Fathoms*, below the *Surface* of our *Earth*, we never miss of *Water*. It is likewise evident from this Figure of the Body of the *Planets*, that the *Surface* of the *temperate Climates* is larger than it wou'd have been, had the *Globe* of our *Earth*, or of the *Planets*, been either *spherical* or *oblongly spheroidical*; so that the Advantage of this Figure is very considerable, the *Surfaces* of the *Polar Regions*, which by reason of the oblique Incidence of the *Rays* of the *Sun* upon them, are colder, and less convenient for the Habitation of *Animals*, and the Production of the nobler Sort of *Vegetables* are

are hereby considerably lessened, and the Surfaces or Space about the *temperate Zones*, which are most comfortable and useful, are thereby considerably enlarged. The same Figure obtains not only in the *Earth*, and the rest of the *Planets*, and their *Satellites* but likewise in the *Sun*, and universally in every fluid Body revolving about an *Axe*.

§ XXVIII. Having shewn some of the Advantages arising from the several Motions of the *Earth*, and the Combination of these, which are common to the other *Planets*, I come now briefly to consider, those that possibly may be more particularly belonging to our *Globe*, and are not the immediate Consequence of its Motions; and the first in order is our *Atmosphere*, of such Necessity toward the subsistence of *Animals*, and the growth of *Vegetables*, that neither cou'd subsist any considerable time without it. This *Atmosphere* is a thin *elastick* Fluid, intermixt with Particles of different Natures, surrounding our *Globe* to the heighth, of about forty or forty five Miles. The Nature and Properties of this Fluid, I have in some measure shewn already. But some of its uses I shall now point out, and first as to *Vegetation*, Dr. *Grew* and *Malpighi* have shewn that it is a principal concurrent therein, and by Experiments on Seeds sown in Earth and put in an exhausted Receiver,

*teiver*, it has been proved that no *Vegetation* can succeed without it, what makes it so necessary seems to be because it being more easily rarified, and heated by the *Action* of the *Sun*, than other more compact, heavy, and less *springy* Fluids, is fitter to promote the Ascent of Juices in the slender Channels of *Vegetables*, and there being no Fluid without a considerable Portion thereof, lodged up and down among its Parts, the first impulse of the Juices upwards, does thence arise. As also because of its active, springy and subtile Nature, it rarifies, actuates and refines the more sizzly *Vegetable* Juices to promote their Circulation and performs Functions, on them *Analogous* to that it does on the animal Fluids. Next as to *Animals* it is well known, that they could live but a few Minutes without this *elastic* Fluid, and probably that which so suddenly kills thunder-struck *Animals*, is the quick and violent Rarefaction of the Air about them; for the *Lungs* of all such upon opening, are found quite destitute of Air, and the sides of their *Vesicles* quite clapp'd together. It's certain, that the Blood is sent from the right Ventricle of the Heart to the *Lungs*, and if the *Vesicles* thereof be not distended or blown up, by the Air, the *Circulation* must stop there, and the *Animal* perish; and both for the Continuance

of the Particles of the Blood, that they may more easily pass through the *Capillary* and terminating Vessels, and for the Propagation thereof in the wider ones, there is necessarily requir'd a Fluid of a determinate Gravity, and *Elasticity*. We have as great Difficulty of Breathing, in a thin (as is evident from the difficulty of Breathing on the tops of high Mountains, and from Experiments on Animals in nearly *exhausted Reservoirs*) as in a thick Air; and ev'n in *Fishes*, where the Water in some measure supplies the want of Air, yet if you draw out all the Bubbles of Air, which are always found in Water, they will languish and die; and in great Frosts, if the Ice be not broken to admit fresh Air, the *Fish* in *Locks* and *Ponds* will languish and die, not to mention here their *Swimming-bladders*, which are so necessary to them, and communicate with the Air in their *Gills*. So that even to them, a certain Portion of this *elastick* Fluid, is necessary. Now how well is this Fluid fitted for the generality of the Inhabitants of this *Globe*? It being neither too heavy, nor too light, neither too much, nor too little *Elastick*, for the uses of Respiration. Another Advantage we reap by our *Atmosphere*, is, that by it our *Clouds* and *Vapours* are supported, without which we shou'd neither have fresh Water, nor Snow,  
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nor Rain, nor any of those things, which moisten and enrich our Soil, and make it fit for *Vegetation*. For tho' it be the *Sun* that rarifies the Water, and makes it take its first flight in *Vapours*, and *Steams*; yet its by the *Atmosphere*, its Progress is continued to the upper Regions, and supported when it is there, to be afterwards form'd into Snow, or Hail, or Rain, or carried into other Regions, whose Soil does want it more. Every Body knows, that if there were no *Atmosphere*, but a perfect *Void*, around the *Earth*, the Action of the *Sun*, wou'd not be able to raise the *Vapours* above a few feet, from its Surface; and that it's only the *Atmosphere's* being *specifically* heavier, than these *Vapours*, that buoys 'em up in the Air, by its greater Tendency toward the Center. Now then, if there were no *Atmosphere*, the *Vapours* cou'd rise to no sufficient heighth, and so cou'd never be cool'd sufficiently, so as to be form'd into Snow, or Rain; for at a small distance from the *Earth's* Surface, the reflected Rays of the *Sun*, make the Places so warm, that no *Vapour* cou'd be turn'd into Snow, or Rain, there; for it's the coldness of the upper Regions, (being destitute of these reflected Rays) and the length of their Descent, that forms these *Clouds* and *Vapours* into Snow, and Rain, whenever the supporting *Atmosphere*  
becomes

becomes lighter, than these accumulated *Vapours*, they fall down with the Temper of Heat or Cold, they had in the *upper Regions*, and so became Snow, or Rain accordingly. So that it's plain, it's our *Atmosphere* that is one of the principal Means of our Dews, and Rains, and all the Blessings, that follow upon these. A third Advantage of our *Atmosphere* is, our *Breezes* and our *Winds*, which carry our Ships upon the *Sea*, and purify our Air, from noxious Steams, which (with the Concurrence of the *Sun*) melt our Snows, and dry our Ground when over-moistned; and serve for so many other Purposes, for the Accommodation of Humane Life. *Wind* is nothing but a violent Motion of the Air, produc'd principally by its Rarefaction, more in one Place than another, by the *Sun's* Beams, the *Attractions* of the *Moon*, and the Combinations of the *Earth's* Motions. Without our *Atmosphere*, we shou'd have no more *Wind* above, than under Ground, and so be depriv'd of all the Benefits arising thence. Lastly, Our *Atmosphere* is the Vehicle and *Medium* of Sound, that Sense which mostly distinguishes us from *Fishes*, and the inferior sort of *Insects*. *Sound* is nothing but a *Modulation* or *Percussion* of the Air, communicated by an impulse, from the vibrating sonorous Body, and propagated in *Undulations*,

dulations, through the Fluid of the *Atmosphere*, ev'ry way round. Without our Air we shou'd not be able to hear the Report of a thousand Pieces or Ordinance discharg'd at the smallest distance, as is evident from the Experiments on Sounds in exhausted *Receivers*. We shou'd have no such thing as Languages or *Musick*, and what a comfortless state this wou'd be, I leave the Reader to judge. Add to all these, that it is to our *Atmosphere* the Beauty, variety of Colours, and Figures, which are painted on the Skies, the Lightfomness of our Air, and the *Twilight* are owing. By it the day is protracted, and the night shortened, and in these places most, which want those most. By the *Refractions* of our *Atmosphere*, the *Sun* rises sooner, and sets later in Appearance, and with its beneficial Consequences, even a Month sooner in some places than it would otherwise. And the Land and Mountains, appear sooner to the weary wandring Sailor. These are great and noble Advantages to the Inhabitants of this Globe, as they best can tell, who by Accidents are sometimes deprived of them. From all which it's very plain that there was *Counsel* and *Design* in the Contrivance and Production of our *Atmosphere*.

§ XXIX. The next thing in Order to be considered is, our *Mountains*, without which  
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it were almost impossible for *Animals* to subsist, or *Vegetables* to grow, they being one of the principal concurrent Causes toward the Production of our fresh-water Rivers. It has been shewn from Calculation, by several Persons, and particularly the ingenious and learned Professor of Geometry at *Oxford*, Dr. *Ed. Halley*, that the *Sun* raises Vapours from the Surface of the Sea, in a Year, sufficient to supply all the Rivers with fresh Water for that time. Now these Vapours being rais'd (the *Sun* acting upon the Surface of the Sea, as a Fire under an *Alem-bick*, by rarifying the same, it makes the lightest, *i. e.* the freshest Portions thereof, to rise with it first; and it rarifies the Water by the Infiltration of its active Particles among the porous Parts thereof, whereby they are put in a violent Motion innumerable different ways, and so are expanded by the compound Fluid of Heat and Air, or hot Air, which carries up with its every little *Volum*, a *Cover* of the more glutinous Fluid of Water which becomes a little *Bubble* of hot Air inclosed within a shell of Water, whereof a great number constitutes a Vapour, which being thus form'd into little *Bubbles* of larger Dimensions than they formerly had, by the intestine Motion raised by the Heat on the Air and Water, which makes their parts turn round their  
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Centers of Gravity, and so to possess more Space, and likewise to fly from one another, and by these means being become *specifically* lighter, they are buoy'd up by the weightier *Atmosphere*) and that this is pretty nearly the Fact, in the production of *Vapours*, may be evident to any one who will view these Vapours raised from common water, by a culinary Fire with a *Microscope*, through a Beam of the *Sun*, which will presently be seen to be innumerable little Bubbles of Water, of different Magnitudes according to the different Force of the Heat in blowing them up. A small Heat throws off but few Vapours, and small Bubbles, a greater Heat, grosser, larger, and more numerous *Globules*. And a very great Heat, so weighty, large, and many *Vesicles*, that the Air is not able to receive and buoy them up, and so produces a boiling in the Water. And every one knows that cold solid Bodies, intercepting Vapours, will condense them into Moisture, watery Drops, and Water. From all which it is evident that *Vapours* may be raised by the *Sun* in such Quantities, as is sufficient to make Clouds, which resting in those Places, where the Air is of equal Gravity with them, are carried up and down the *Atmosphere*, by the Course of that Air, 'till they at last hit against the sides of the more eminent and

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*Mountanous* Places, of the *Globe*, and by this Concussion are condensed, and thus become heavier than the Air they swim in, and so gleet down the rocky Caverns of these *Mountains*, whose inner Parts being hollow, and stony, afford them a *Basin*, 'till they are accumulated in sufficient Quantities to break out at the first *Crany*; whence they descend into the Plains, and several of them uniting, form Rivulets, and many of these *Rivers*; so that it is evident the great Benefit of these Eminences is not, that by the Shock these Vapours get in their Course from them, they are condens'd, so as to be precipitated thereby through the Chinks of the Rocks, but that afterwards in their Bowels they are preserv'd, 'till they be of sufficient quantity to form Rivulets, and then *Rivers*; for doubtless our Vapours wou'd fall in Rain, and Dew, tho' there were no *Mountains*, but then they wou'd fall equally, over considerable Places of the *Globe* at once, and so wou'd be suck'd up in the Ground, or make an *universal Puddle*; whereas by these *Mountains*, they are perpetually almost, (at least a Nights) pouring down in some particular Places, and there treasuring up, for a constant Supply to the *Rivers*. Not that other Causes may not concur toward the Production of Fountains, Rivers, and fresh Water, besides the raising of Va-

pours by the Heat of the *Sun*, to descend in *Rains*, *Mists*, and *Dews*. They might be raised from the *Sea* by *Subterraneous* Heats, and percolated from their Saltness, by being strain'd through Earths and Layers of Minerals of different Natures; but it is not easy to conceive, how any straining can bring salt Water to that degree of freshness, our Rain, and Snow Water is brought. All the artificial strainings, tho' never so often repeated, and through whatsoever kind of Sands or Earths, hitherto discovered and made use of, still leave a *Brakishness* in salt Water, that makes it unfit for *Animal* uses; neither does there appear any kind of natural Operation, sufficient for this purpose, but this natural *Sublimation* and *Distillation* of Vapours into *Dews*, *Mists*, and *Rains*, which makes it very probable that this is the principal efficient in the Production of Rivers and Fountains. As to the *perpetuity*, and *equability* of some Fountains, where there are no considerable Mountains over and above what is to be expected from the uncertain and unequal falling of *Rains*, *Mists*, or *Dews*, nothing can be concluded from thence, unless the Extent and Capacity of the *Reservoirs* of falling Rains in the Bowels of the Earth were certainly known. For the fresh Water may be convey'd to so great a distance, and in such a quantity,  
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and to so great a depth, by the situation of the internal Channels, as may be sufficient to raise it in larger Streams, than any Fountain Head as yet known can send out, and the depth and distance of the Basin may hinder it from sending out *Sensibly*, more Water at one time than another. Tho' if the Quantity were precisely the same at all times, in these *perennial* Fountains, the difficulty wou'd be greater. However, whatsoever the Origin of Fountains may be, still Hills are the *Reservoirs* in this great Work. Another very considerable use of these *Hills*, and *Eminences*, is the Determination of these Rivers; for tho' there had been Rivers without Mountains, (which is hardly possible) yet in that case the Rivers cou'd only have run in a straight Line, if they had run at all; whereas, by these *Eminences*, plac'd up and down the *Globe*, the Rivers make innumerable beautifying turnings and windings, whereby they enrich, fatten, and water the Soil of several different Countries in one Course, make the Transportations and Carriage over Lands more easy and manageable, and at last disembogue in several Mouths into the *Sea*; where, by the assistance of the *Tides*, they form Harbours and Ports, for the convenience of *Shipping* and *Naviga- tion*. All these Advantages we have by our *Mountains*; for tho' from other Causes,

we might possibly be supply'd with fresh Water Springs, (tho' Nature seldom is *Luxuriant* in diversity of Causes) yet without our *Mountains* we cou'd never have Rivers, nor cou'd these Rivers have such delightful turnings, nor those useful falls, which gives them an impetuosity that may be improv'd to so many delightful as well as profitable Uses. Lastly, If we consider what these Hills in their own Nature and Cause are, we shall plainly perceive their Necessity and Use: A Hill, is nothing but the *Nest* of some *Mettle* or *Mineral*, either of *Stone*, *Iron*, *Tin*, *Copper*, or such like lower *Vegetables*: These *Mettals* and *Minerals*, by a *plastick* Virtue proper to themselves, and the efficacy of *subterranean* Heat and Fires, converting the adjacent Earths into their Substance, do encrease and grow as truly as *Animals* or *Vegetables*, and requiring free Passage both for Air and Water to assist in their formation: By their Growth, and the Heat of the *subterranean* Fires, raise and push upward the Surface of the Earth according to the necessity of their Nature, and the quantity of the *Metallick* or *Mineral* Bed. I do not say that all Mountains owe their *Origin* to such Causes, *subterraneous* Fires have thrown up Mountains of *Mineral* and *Metallick* Beds, already form'd, the *Sea* and *Tides* have thrown up Banks and Bays of Stone and Sand, Currents

rents and Streams in proper Situations, meeting and justling have form'd Eminences of different Sizes and Matter: And Art and humane Industry has raised some. But generally and for the most part, all the eminent Mountains are found to be Nests, and Beds of *Minerals* and *Mettals*, which have large hollow Cavities, for Water and Air, and whenever they have been digg'd into, these have been found in them, with all the appearances of some parts of them a forming and growing in a manner proper to them, and *analogous* to the Vegetation of Plants. The manner how they are produced is not here necessary to be enquired into, but that *Mettals* and *Minerals* are encreased and do grow is past all doubt, and is confirm'd by all Miner's and Diggers: And that there may be *subterraneous* Heats sufficient to raise them into *Hills* and *Mountains*, is evident from some, so formed near *Vulcano's* and burning Mountains: And the Force and Violence with which these Burn and throw out such Masses of *stony*, *sulphurous*, and *earthy* Matter. From all which it is evident our Mountains are as necessary as our *Mettals* and *Minerals* are. I do not mention here their use and advantage for the production, shelter, and nourishment of some sorts of Vegetables and Animals which cou'd not grow or live so well any where

else. But from the whole we may see of what Advantage these unsightly Mole's (as some thought them) are to the Accommodations and even Necessities of living.

§ XXX. Next come our Fluids to be considered, without which we cou'd never have been, seeing they are a very *essential* part of us; that which I shall principally take notice of, is, 1. The fewness of the *original* and *primary* Fluids, in respect of that vast Number of compounded ones, which are indeed numberless. The *primary* ones hitherto certainly known, are only four, *viz.* *Air, Water, Mercury* and *Light*; three of which are but seldom much compounded with others, so that it is *Water* alone, or *Lymph*, that is the *Basis* of all our Mixtures, and it is the parts of solid Bodies floating in this Fluid, that produces all our delightful and useful varieties of Liquors; so frugal is Nature in *Principles*, and so fruitful and various in Effect and Compositions. 2. The great difference between the *specifick* Gravities of our Fluids, *Mercury* being about 8000 times heavier than *Air*. Now not to mention the many uses of this last Fluid in Artificers Works, had *Air* been as heavy as *Mercury*, it had been altogether useless in Respiration; on the contrary, it had choaked us immediately; and had there not been a Fluid of the same weight with *Mercury*,

ii. e. a collection of exceeding small, vastly heavy *Spherules*, in the present Circumstances of Mankind, I do not know what a great part of the World would have done. For the Lewdness and Debauchery of Mankind, has brought a great many Diseases to that degree of Malignity, that I scarce see how a thorough Cure cou'd be made of 'em, without this Fluid; for it's certain whenever any Distemper arises from an obstruction of the Blood Vessels, wherein the Blood and its Vessels, are chiefly concerned (for in *Nervous* Cases I am satisfied it is pernicious, in great Quantities especially) that this Fluid, if not absolutely necessary, is extremely beneficial; for nothing has sufficient force to take away this obstruction, and to separate the *Globules* from one another, in the extreme *capillary* Vessels, but a little weighty *Sphere*, such as the Particles of *Mercury* certainly are. Now by this difference of the *Specifick* Gravity of the Fluids, a Remedy is provided for all these Maladies, which I am satisfied are more than two or three. But that which is most wonderful in these Fluids, is, 3. The universal condition of the direction of their *Pressure* upon the sides of the containing Vessel; for in all Fluids of whatsoever kind or nature, this *Pressure* is communicated in Lines *perpendicular* to the sides of the containing Vessel.

fel. Now this property of Fluids, which is so beautiful and uniform, is the necessary Consequence of the *Sphericity* of their constituent Particles; for since by the third Law of Nature, *Reaction* or *Repulse* is always equal and contrary to *Impulse* or *Action*, in the same Direction, consequently the sides of the containing Vessel presses the contain'd Fluid, as much as the contain'd Fluid presses the sides of the containing Vessel; and this *pressure* of the sides of the containing Vessel, is directed in the same right Line with that of the contain'd Fluid, but is contrary to it. Now seeing a *right Plane*, can only touch a *Sphere*, in a point, and can press it in a direction through that point of Contact; if this Direction through the point of *Contact*, do not likewise pass through the Center of the *Sphere*, the *Sphere* will necessarily revolve upon *Plane* till the Direction of its *pressure*, from the point of *Contact* pass through the Center of the *Sphere*; just so likewise, if a *Plane* press two *Spheres*, in the same Direction, the Line of this Direction will necessarily pass through both their Centers. And so if there be any number of *Spheres* whatever, press'd by a *Plane* in the same Direction, the Line of this Direction will necessarily pass through all their Centers. But a Line through the Center of a *Sphere* from the point of Contact, is  
perpen-

*perpendicular* to the *Tangent Plane*; and since this is the *Direction* of the *pressure* of the *Plane* upon the *Spheres*, it is also the *Direction* of the *pressure* of the *Spheres* upon the *Plane*. Since also the *Particles* of *Fluids*, are *Spherical*, or nearly approaching thereto, and since they are suppos'd exceeding small, as also since *curve* surfaces are compounded of an infinite Number of little plain surfaces, it is universally true, that all *Fluids* of what nature soever, press the sides of the containing *Vessels* in a *Direction perpendicular* thereto. And on the other hand, since by *experience*, it is found true, that *Fluids* do press the sides of the containing *Vessels*, in a *Direction perpendicular* thereto, it's certain that the *Particles* of all *Fluids* are *Spherical*, or nearly approaching thereto; so that this is now no more *Hypothesis* but *Demonstration*. Now cou'd any thing but the *Fingers*, and *Almighty Power* of *God*, have rounded those infinite numbers of small *Particles*, whereof *Fluids* consist? Or cou'd any thing but his *Wisdom*, have assign'd them their true dimensions, their exact *Weights* and requir'd *Solidities*? We shall allow him to continue in his infidelity who can demonstrate by what *Laws* of *Mechanism*, all the *Particles* of *Water* were turn'd of the same *Diameter*, *Solidity* and *Weight*, and those of *Air*,  
*Mercury*

*Mercury* and *Light*, turn'd all of different *Diameters*, *Solidities* and *Weights* from one another; but all of the same *Diameters*, *Solidities* and *Weights* among themselves.

§ XXXI. What a noble representation of the Divine Wisdom does our Fluid of *Light* afford us! how wonderfully are its parts fram'd! and with what a prodigious *velocity* are they sent from the Body of the Sun! its *Subtility* is almost beyond imagination, no Pore so small as to exclude it; no Stream of it so great, but may be congregated almost into a single Point; no Surface so finely polished, as not to scatter almost one half of it; its Rays traverse through one another, millions of different ways, without interfering ev'n in the straitest Passages; in one Word, we are not able to comprehend nor imagine a Number sufficiently small, to express its subtility; in every pulse of an *Artery*, it runs some *hundred and thirty thousand Miles*; what an amazing, and unconceivable *velocity*, must this be! nothing but the action of the Mind, can any ways represent it: And then what a beautiful *Idea* of this Fluid, do Sir *Isaac Newton's* later Discoveries present us with, ev'ry Ray is endow'd with its own *Colour*, and its different degree of *Refrangibility* and *Reflexibility*. One Ray is *Violet*, another *Indigo*, a third *Blue*, a fourth *Green*, a fifth *Yellow*, a sixth *Orange*, and

the last *Red*. And these are the *primary* and *original Colours*, and from the mixture of these, all the intermediate ones proceed, and *White* from an equable mixture of the whole; *Black* on the contrary, from the small quantity of any of them being reflected; or, all of them in a great measure being suffocated. So that now it is not Bodies that are coloured, but the *Light* that falls upon them, and their Colours arise from their *Aptitude*, to reflect Rays of one Colour, and transmit all those of another. Their prominent little parts, upon their Surfaces, according to their different Degrees of *density* and *thinness*, are apt to reflect back upon our *Organs*, Rays of one Colour, and of one degree of *Refrangibility* and *Reflexibility*, and to let others pass through their Pores; and this one Colour too, is less or more intense, according as their prominent parts are of different *densities*, or are thicker or thinner. For the first degrees of *Intenseness*, in all the *primary* Colours, seem to arise from some determin'd degrees of *density* and *thinness*; and the subsequent degrees from the other different degrees of *density* or *thickness* or *thinness*, of the prominent little parts, of the Surfaces of Bodies. *Light* acts upon Bodies by heating, dissolving, and putting their parts in a *vibrating* Motion; as also Bodies act upon *Lights*,  
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in drawing its parts to them, and that in Lines *perpendicular* to their Surfaces: All the differently *reflexible* Light, observes this one Law, that all the different *Angles* of *Incidences* are respectively equal to the *Angles* of *Reflexion*; and all the differently *Refrangible* Rays of Light, observe one Law likewise, *viz.* that in all the *obliquities* of the same Ray, to the Plane of *Incidence*, the *Sines* of the *Angles* of *Incidence*, are to the *Sines* of the *Angles* of *Refraction* in a constant *ratio*; and both these Properties proceed from one, and the same Principle, acting in different Circumstances, *viz.* that Bodies attract Light in Lines *perpendicular* to their Surfaces, and that this attraction is equal in all the *Incidences*, and *Refractions* at equal Distances from the same Plane, and the *reflected* Rays are turn'd back before they arrive at the *reflecting* Plane: For if the *reflecting* Plane, have such a force of *attraction*, that before the Ray arrives at it, it has already made the *Sine* of the *Angle* of *Incidence*, equal to the *Radius*, the Ray must reflect, and not enter into the reflecting Plane at all; if a lesser degree of *attraction*, then must it enter the Body of the Plane, and proceed in the Line, that its direct *impulse*, together with the degree of *attraction* in the *refracting* Body, necessarily generates. And as there

there may be different degrees of *Attraction* in Bodies, which produce their different degrees of *Elasticity* and *Cohesion*, so there must be different degrees of *attraction* in *Mediums*, suppos'd, to account for their different *Powers*, in bringing the *refracted* Rays nearer to or farther from, the *perpendicular*; for it's well known, all *Mediums* have not the same *refractive* Virtue. Now what a beautiful, uniform, and simple *Theory* of *Light*, is here? this is so very like the *frugal simplicity*, and yet the *manifold variety* of Nature, that one would be almost tempted to believe it true, were there no *Demonstration* and *Experiment* to confirm the truth of it. I might likewise shew here the Art and Contrivance of Nature, in the production of the *Cohesion* of Bodies. But having been pretty copious on this Subject already, I shall only suggest one very remarkable Instance of the wonderful Contrivance and Wisdom of Nature, in the *propagation* of *Light*, viz. that a Ray of *Light*, in passing from a luminous Point, through two differently *refracting* *Mediums*, to illuminate a given Point; spends the least time (the *refracting* Powers of the several *Mediums* considered) possible, and consequently when the Rays passes, but through one and the same *Medium*, *i. e.* when a Ray passes from a luminous point, to reflect upon a given

given point, it takes the shortest way possible. This the *Geometers* have demonstrated, and particularly, Mr. *Hugens* in his *Treatise of Light*, very elegantly page 40 and 41. Now I appeal to the Reader, how *incredulous* soever, if this be not an Instance of *Counsel* and *Design*, is not this like the Methods of *Prudence* and *Wisdom*, which will not spend more time on a thing, than just what is necessary to do the Business; which will not go about, but take the shortest Course possible, that will bring it to the place design'd? He that can resist such pregnant and powerful Instances of Divine Wisdom, will never be convinc'd.

§ XXXII. I should next proceed, to shew the wonders in the *Bowels* of our *Earth*, but there our Discoveries are so few and our accounts of this matter, so lame, that little to be reckon'd certain, can be determin'd about these *Inner Regions*. Some have concluded that there must of Necessity be a Central heat, because they saw that Springs run faster in Frost and Snow, than in hot Weather, but that might proceed from some of the other more narrow *outlets* of this *Basin's* being stop'd, by the Frost; and the *Vapours* that the Sun raises thence, being kept in. Others have thought that within this outer *Crust* of *Earth*, there must be a *Discontinuity*, for some considerable distance,

stance, quite round, and that there was succeeding this, a large *Sphere*, moving after a certain manner, to account for the *variation* of the *Magnet*; what Truth may be in that we must leave to Time and future Observations to determine. But the *Magnet* in it self is a beautiful Instance of the Power and Contrivance of the *Author* of Nature, of the reality of *Attraction* in general in Bodies, and that different from their Gravities; and of their imperceptible Influences upon one another. For this wonderful *Fossil* not only attracts and repels *Iron*, and all *Chalybeat* Compounds, and all other *Minerals* of the same Nature with it self, according to their different Situations in respect of its *Poles*. But when *Iron* is duly impregnated with the Virtues it communicates, and properly managed, its Extremities at sometimes points directly *North* and *South*, and thence varies both in the same and in different places of the *Globe*, in regular and uniform Figures, towards *East* and *West*, according to the *System* of these Variations discovered by the *Learned and Ingenious* Dr. *Halley*. And very probably, as the common *Horizontal* Needle, is continually varying towards *East* and *West*, so the dipping or inclining Needle is varying up and down, towards or fromwards the *Zenith*, according to the Suspicions of the *Lear-*

ned and Reverend Mr. Derham, and possibly in a regular and uniform *System*, and there may be other beautiful and regular Qualities not yet discovered, in it all these mentioned being found out within less than 500 Years. There is a Ring about *Saturn* which moves differently from his Body that somewhat favours this Supposition of *Interior Orbs*, but I cannot come into the Opinion that this *Annulus* may be some remains of the Ruins of a Crust, that is fall'n in upon the Body of the *Planet*, because this Ring appears to be regular and uniform, of an equal breadth quite round, and at an equal distance from the Body of the *Planet*; besides, it is scarcely probable that these *Planets*, which like ours, may be design'd for the Habitation of some sort of *Animals*, shou'd be so ruinous as this Supposition wou'd make that *Planet* to be. If it be true that all the Bodies of the Universe attract one another, and if it be very probable from the Benefits of our *Moon* to the *Earth*, that such like and *analogical* Advantages, of raising Tides in the Fluids, reflecting Light in the Night Seasons, and emitting other Influences for Life and Vegetation, accrue to the *Planets* from their *Satellites* and other *Appendages*, then it's very plain that whenever a lesser Body (however figur'd) attends the Motions of, and revolves with a greater,

ter, that that lesser Body is design'd by its *attraction*, and Influences to produce some effect, that is the Consequence of this *Attraction* and these Influences. Thus it's plain, our *Moon* was design'd to raise our *Tides*, and regular Winds, to enlighten our Nights and to disturb the Motions of our *Earth*, for Purposes that possibly we may, or may never, come to discover; and so the *Satellites* of *Jupiter* and *Saturn*, were design'd to attract their Fluids, and to enlighten their Nights, or disorder the Motions of their respective *Planets*; or to produce some effect consequent upon Attraction, and I have suggested before, that the Multitude of the *Satellites* of these *Planets* may serve in their vast distance from the *Sun*, to hinder their Fluids (by frequent and various Disturbances) from freezing; and to enlighten their long tedious Nights, and the greater number of the *Satellites* of *Saturn*, than *Jupiter*, seems to favour this Conjecture. Now this *Anulus* may possibly serve some such purpose as this, since it moves differently from the Body it self. But all these are but Conjectures; and as such I leave 'em. It's probable that *Earthquakes*, and *Vulcano's*, proceed from some Motion and Mixture of different Particles within the Body of the *Earth*; for as to a *Central Globe* of Fire, it is not easily to be conceiv'd how it can

subsist without Air or Fewel, or without consuming the contiguous Parts of the *Globe*, and if it had either Air or Fewel, it must make a greater Havock, than any History mentions. Besides, that it cannot well consist with these mention'd *interior Orbs*, without confounding their regular Motions: All the Appearances of Nature which seem to require it, may be more naturally solved by the *Fermentation* of different Steams and Vapours, within the Cavity of the *Earth*. These *Vulcano's* and fiery Eruptions, never happen but where Sulphur and Iron are copiously found, which we are certain may produce Heat and Flames when duly mixt and fermented, any where: And it's observable that there are scarcely any Country much annoyed with Earthquakes that have not one of these *fiery Vents*; which shows that these *Vulcano's* are the necessary Consequences, and the *Tunnels* of the fermenting Vapours, in the Bowels of the *Earth*, and not Chimneys to the Central Heat: And this by the way is a bountiful Contrivance in Nature, to lessen and evaporate these tumultuos Steams, which otherwise might make much greater Havock than now they do. Earthquakes and *Vulcano's* in the Earth being the same that Thunder and Lightning are in the Air, and from the same Causes: It is likewise probable that its *Strata*,  
ta,

*ta*, are not of such Gravities as a regular subsidence according to the Laws of Gravitation of Bodies, wou'd require; which shews it has not been compounded by these Laws. It's certain, that we have fresh Water at any considerable depth, in most Places distant from the *Sea*; which shows how uniformly and equally this so absolutely necessary Fluid has been distributed for the Benefit of the Inhabitants of this Globe; we have from its *Bowels*, all those *Metals* and *Minerals*, with all their varieties, which are of so much use, for the Accommodations of *Life*, and the subservience of *Medicine*; from the depth of the *Sea*, and the *Bowels* of the *Earth*, we have all our natural *Salts*, which do us so great and manifold Services. If any one had but occasion, to look over the variety, beautiful Figures, and Colours of *Shells*, *Petrifications*, *Ores*, *Minerals*, and *Stones*, and other natural Curiosities, (of which the noblest, and largest Collection, possibly now extant, is to be seen, in the Possession of the *Industrious and Learned Dr. Sloan*) he cou'd not but admire the *manifold Wisdom* of the Author of Nature. This were a very large and copious Field, and wou'd afford very *demonstrative* Instances of *Counsel* and *Contrivance*. But I have so many other things to suggest on the Head I am about, that I must content my self with *Generals*.

## CHAP. VI.

The Proofs for the Being of a  
 God, arising from the Contem-  
 plation of the Humane Stru-  
 cture.

§ XXXIII. **H**AVING dwelt so long upon the *inanimate* part of this *System* of things, I come now to consider the *Animal Kingdom*; that *noble* and *manifest Representation* of the *Power* and *Wisdom* of the *Author of Nature*. One of *Democritus* or *Des Cartes's* Disciples, may perhaps undertake to give some faint and imperfect kind of *Explication* of the *Celestial Appearances*, from their *Principles*, tho' how wretched their accounts of this Matter are, we have in some measure already shewn. But when they come to a *Plant*, or *Animal*, they are perfectly at a loss, they can produce nothing coherent, or of a piece; their *Schemes* then, are like the effects of the casual *concourse* of *Atoms*, an odd inconsistent Mixture of things, that has neither *Form*, nor *Beauty*. For ev'ry part of these, is so exactly adapted, to some  
 wise

wise *Design*, ev'ry thing is so fitted, to its own proper use; and these Uses are so manifest and evident, that they clearly argue, an infinite *Wisdom*, an exact and exquisite Knowledge, in the Laws of a Divine *Geometry* and *Harmony* infinitely superior to our low Figures and Numbers, that nothing is sufficient for, but a *Being* absolutely perfect. I shall here, as I did in the *Celestial Philosophy*, give some general *Scheme*, of the *Animal Fabrick*, and *Oeconomy*; and shall confine my *Speculations*, to the *Humane Structure*, as being the most perfect, we are acquainted with, and which being fully understood, the rest will easily follow. I shall begin with the process of the *Aliment* and the *Circulation* of the Blood.

§ XXXIV. The Meat being grossly divided by the Teeth, and softened by the *Saliva*, is through the *Gullet*, by the Constriction of its *Fibres*, thrust into the *Stomach*; where being swell'd and farther softened by the *Succus* of its *Glands*, and the Liquors taken in, by the perpetual Motion of the Coats of the *Stomach*, against one another, the *Muscles* of the *Midriff* and *Abdomen* employed in respiration, and possibly from other Causes, never to be known, its parts are broken, and their intimate Cohesions dissolv'd. And by this *pressure* of the sides of the *Stomach* upon the contain'd *Aliment*, it is

thrust into the *Intestins*; at its entry into which, it is irrigated with the *Bile* and *Sweetbread-juice*, the one to sweeten, the other to dilute the *Chyle*, by the *vermicular Motion* of the *Intestins* (arising from the alternate Action of their *Spiral* and *Longitudinal Fibres*) the pressure of the *Midriff* and the *Muscles* of the lower *Belly*, the grosser parts are deriv'd downward, to be thrust out of the *Body*, while the finer, are squeez'd into the narrow *Orifices* of the *laeteal Vessels*, which open into these *intestines*; whence in slender Channels they are carried into the *Glands* of the *Mesentery*, receiving first a fine thin *Lymph* from the *Lymphatick Ducts* which dilutes this *Chylous* fluid, and scours its containing *Vessels*, which from the *Mesenterick Glands* unite in larger Channels, and pass directly into the common *Receptacle* of the *Chyle*, which is a *Bason*, form'd for it by the *Union* of these *Laeteal*, and *Lymphatick Vessels*; from thence in one *Duct*, it ascends into the *Thorax*, and about the *Heart* sometimes dividing, it immediately unites again, and creeping along the *Gullet*, it passes on to the left *Subclavian Vein*, where in one or two *Mouths*, it opens into that *Vessel*, and there mixes with the *Blood*, and *circulates* with it, which *Circulation* is thus perform'd. The *Veins* (in a continued Channel, as is reasonably

reasonably to be supposed, with the *Arteries*,) bring the Blood from the Extremities of the Body, and all uniting in two large Vessels, whose sides diverge, from the *Vena Cava*, *Ascendens* and *Descendens*, which two likewise join at their entry into the right Ear of the Heart, which in its *Relaxation* or *Diastole*, receives the Blood from them, and in its *Constriction* or *Systole*, thrusts it into the right *Ventricle*, which is then in its state of *Remission*: Which when contracted, drives it through the *Arteria Pulmonalis*, into the *Lungs*; whence it is receiv'd, in an uninterrupted Channel, by the *Vena Pulmonalis*, and is carried into the left *Auricle* of the Heart, then open to receive it; by whose *Constriction*, it is discharged into the left *Ventricle* then likewise dilated, by whose contraction it is pushed into the *Aorta*, which bending a little upwards, sends forth the *Cervical* and *Axillary Arteries*, the rest turning down again, forms the descending Trunk, and these dividing into innumerable lesser Channels, carry the Blood to the several parts of the Body, where leaving some of it's Particles proper for their use; the rest is sent into the *Veins*, which are nothing but the returning *Arteries*; and thus the Blood is carried about in a perpetual *Circle*, from the *Arteries* into the *Veins*, and from these to those;

those; and in this *Circulation*, duly perform'd, *Life* and *Health* consist.

§ XXXV. As it is plain from what has been said, that it is only the *Blood*, that is immediately recruited by the *Chyle*, so is it likewise evident from thence, that it is only from the *Blood*, that all the *Expences* of living are furnished, and that all the *Secretions* of what kind soever are deriv'd. Now these *Secretions*, are made by the assistance of the *Glands*, and a *Gland*, is an *Organ* consisting of some one or more *Turns*, *Folds*, *Convolutions* and *Contextures* of *Vessels*, in a proper *Membrane*, for the separation of one *Liquor* from another. The most conspicuous *Gland* of an *Animal*, is the *System* of the *Guts*, where the *Lacteals* are the *emissary Vessels* or *separatory Duets*: The *Mesentery* is the *Membrane* that keeps them in their natural *Situation*, and the *Peristaltick Motion*, the several *Convolutions*, with the *Valves* of these long hollow *Channels*, are the *Mechanical Apparatus*, whereby the *Chyle* is separated from the *Food*, and carried into the common *Receptacle*. The *Testicles* when unfolded, give us another plain *Conception*, of a *Gland*, where the *Artery*, after having sent the greatest part of the *Blood*, by many little opening *Branches*, into the nearest *Vein*, is carried on in a *Cylindrical Figure*, through many  
Foldings

Foldings and Plies, conveying through its single *Tube*, the proper *Liquor* into a common *Basin*. There is, no doubt, as great a variety of *Structures* in the *Glands*, as the different *Liquors* to be separated are, for since the *Arterial Blood* is the common *Subject*, the *Diversity* of the separated *Liquors* must depend on the different *Structures* of these *Strainers*. Some, no doubt, are very *Simple*, such perhaps are the *Glands* of *Perspiration*, where a little *Tube*, jetting out from the *Extremity* of an *Artery* where it degenerates into a *Vein*, may be sufficient to carry off these *Vapoury Steams*, of the *Blood*; tho' even here, *Anatomists* have observed *Art, Contrivance, and Complication*. But the still more complicated, seem to consist of a *Membrane*, forming (by the contexture of *Blood, Vessels and Nerves*) an oval or round *Basin*, for receiving the separated *Liquor*, and of two or more *Ducts*, for conveying in, and carrying out of this *Cavity*, the separated *Liquor*. This *Membrane*, is as it were a *Stay and Base*, for the *Blood Vessels and Nerves*, to keep them in their natural *Situation*; and to form the *Cavity*. Here, the *Blood Vessels* are interwoven into different *Figures, Situations, and Inosculation*s, according to the *Necessity* of the separated *Liquor*. There are other *Glands* again, yet still more complicated, but they  
are

are commonly no other, than a Mass of the former, contain'd under one common involving *Membrane*, and having all their *emissary Ducts*, united in one large common *Vessel*, which may enter into another *Gland*, as an *Artery*; and so a new Separation may be made, from the former separated *Liquor*. I will not assert any thing positive about the *Mechanical* Explication of the separation of one *Liquor* from another in an *Animal Body*. All I have hitherto seen on the *Head*, being either too general or too precarious: But something like these three Conditions, seems to enter into this Disquisition. 1. The different *Diameter* of the *Orifice* of these *Secretory Ducts*, whereby *Particles* of a *Diameter*, greater than that of this *Duct*, are excluded. 2. The different *Angle*, which this *Duct* makes, with the *Trunk* of the *Artery*; for it is already demonstrated, that all *Fluids* press the sides of the containing *Vessel*, and that in a direction *perpendicular* to these sides; and this is evident in the *pulsation* of the *Arteries*, since it is, to that *pressure*, this *pulsation* is owing. It is likewise evident that the *Blood* is urg'd forward by the *Force* of the *Heart*, so that the *Motion* of *Secretion* must be compounded of both these *Motions*. Now tho' this *lateral pressure*, is greater, when the *Velocity* of the *longitudinal Motion* is so, yet  
it

it is not in the proportion of this *Velocity*; for this *pressure* is always somewhat even, when the Fluid is at rest, and is then in *proportion*, to the *Specifick* Gravity of the Fluid, nothing else being in this Fluid to produce this *pressure*, and in a Fluid urg'd by a *Longitudinal* Direction, as the Blood in the *Arteries*, this lateral *pressure*, is in a compound proportion of both; whence it is evident that if two Particles of equal *Diameters*, but of unequal *specifick* Gravities, arrive with the same *Velocity*, at an *Orifice* capable of admitting either of 'em, yet they will not both pass, because their *Motion of Direction* is different: So that this Diversity in the *Angles*, these *Secretory* Ducts make with the *Trunk* of the *Artery*, seems altogether necessary to account for the possible Diversities of secern'd Fluids, ev'n admitting their *Diameters*, and *Figures*, to be the same. For it is not to be doubted, that the Blood is a *Hetrogeneous* Fluid, and contains parts of different *Specifick* Gravities, different Cohesions, and of different *Densities*; and the separated Fluid must be nearly *Homogeneous* to perform the uniform Functions of Life. 3. The different *Velocities*, with which the Blood arrives, at the *Orifices* of these *Secretory* Ducts, for since the *Secretions* are made in form of a Fluid, there is no possible Reason can be assign'd, why some

some *Animals* of the same Species are of a soft loose Texture, and Union of solid Parts, and why one part of the Body is of a tender, loose, easily separable Texture; others of an harder, firmer, and more close Cohesion, but this different *Velocity* of the Blood, at the *Orifices* of the separatory Ducts. And tho' the Diversity of the *Diameters* of these Ducts, is certainly that which is of greatest *Moment* in this Affair of *Secretion*, yet it is impossible to account, for the *similarity* of the secern'd Fluids from so *Heterogeneous* a Fluid, as the Blood is, from this alone. For suppose, (as my worthy and learned Friend Dr. Cockburn has very justly reasoned) the *Diameters* of the Particles of *Urin*, *Gall* and *Semen*, to be as 1, 2, 3. The *Diameters* of the *Secretory* Ducts, of the *Kidneys*, *Liver* and *Testicles*, must be in the same *Proportions*. Now tho' upon this supposition of only different *Diameters*, the Particles of *Gall* and *Semen* cannot be separated in the *Kidneys*, yet the Particles of *Urine* and *Gall* may be separated by the *Excretory* Ducts of the *Testicles*, the *Diameters* of the Particles of the Fluids, being by supposition, less than that of the *Diameter* of the *Excretory* Ducts of the *Testicles*. So that upon this supposition of only different *Diameters*, it is impossible to account, for the *Homogeneity* or *similarity* of the se-  
cerned

*cerned Liquors*: For all the Particles of whatever kind, that are less than the *Diameter* of the *Secretory Duct*, must be indifferently separated there. *Nutrition* may be perform'd by a *Secretory Duct*, arising from the terminating *Artery*, which carries a suitable Portion of the Blood, to every part to be nourished, so that ev'ry point in the Body, must be the *termination* of a *Secretory Duct*; through which a proper part of the Blood is brought. The Blood in its *Circulation*, being carried into the Cavity of the *Skull*, in the Branches of *Carotid* and *Cervical Arteries*, these are divided into innumerable *Ramifications*, so as to become extremely small: Their last *Extremities* after the manner now described, form a little *Gland* (all these little *Glands* together make the *Cortical* part of the Brain) terminating in two little *Vessels*, one for carrying back as a *Vein*, the grosser part of the Blood; another as an *Emissary Vessel* to each of these *Glands*, distributing throughout the whole *System*, the more pure, refin'd, and subtile part of the Blood, (as is suppos'd) which is then call'd the *Animal Spirits*. All these little *Emissaries*, united together at their Origin (the *Cortical* part of the Brain,) make that Substance, which is called the *Medullar* part; being a Bundle of very small, thread-like Channels, or  
Fibres,

Fibres, some of which are carried through their proper Cavities, in the *Skull*, for the use of the *Organs* of Sensation; the rest through the Cavity of the *Spine*, to be distributed at proper places, through the rest of the *System*. It is not impossible but these *Emissary* Vessels of the small *Glands*, whereof the *Cortical* part of the Brain consists, may contain a Liquor, and that this Liquor may be the more refin'd, and subtile part of the Blood; especially if we reflect that *Nature* does nothing in vain, and that these *Glands* differing scarcely at all from those others, which we certainly know separate proper Liquors, but in the length of their *Emissary* Vessels (the necessity of which in the present Case is self-evident) and that the Blood Vessels, being sent in such Numbers into the Brain, and in a much greater proportion, than to any other part of like Dimension, and being there form'd into the mentioned *Glands*, and these *Glands* sending out these small *Emissary* Vessels, over the whole *System*. It is not impossible I say, that these may carry a suitable Liquor. For 1. almost the whole Mass of Blood, in a little time is brought to this *Cortical* part of the Brain: (The most subtile, most spirituous, lightest, and most moveable part of the Blood, ascending by the *Carotid* and *Cervical* Arteries; the grosser, heavier and  
least

least active, descending toward the lower parts, by reason of the Situation; and the greater *specifick* Gravity of these last parts of the Blood.) 2. In the *Medullar* part of the Brain is often found on Dissection, a thin, whey-like substance, which Fire hardly thickens. 3. The Nerves, are equally distributed all over the Body, are absolutely necessary toward all Motion, Natural and Voluntary, and 4. They are the *specifick* *Organs* of Sensibility. All which seem to imply that they are the containing Channels, of some Liquor; and then possibly this Liquor may be something a kin, or *Analogous* to those Spirits we gather from animal Substances, by Heat in an *Alembick*; Such as are Spirits of *Sal Armoniack*, *Hartshorn*, *raw Silk*, or *Humane Skulls*; and what renders this Conjecture more probable, is the not altogether dissimilar *Apparatus* in forming these *animal Spirits* in the Brain, from that of drawing those others, in an *Alembick* by Fire; and the wonderful present Efficacy, these last have on the first; and that both are equally unalterable, by Heat and incapable of Burning. But then if we consider on the other Hand, that these *nervous Fibres* serve equally, and administer unto Nutrition, local Motion, and Sensation; this last Function seems intirely opposite to the Nature of a Fluid, necessarily acting in the

other two Functions from within to without, and in this last from without to within. Add to this, that this nervous Fluid has never been discovered in live Animals by the Senses however assisted: Nor it's necessity evicted, by any cogent Experiment; and that *Leuwenboecks* Experiments makes the Fibres, or the last Channels of this Fluid, so infinitely slender, small, and spongy, that considering the resistances from the sides of the Vessel, in small tubes: It seems absolutely impossible, any Fluid (such as we have any *Idea* of) cou'd move with Velocity to answer the Appearances; so that after all, it seems pretty difficult to come to any certain Conclusion on either side. But either the Fibres, contain a pretty consistent Fluid whereof they are constantly full, and then the least drop forced into the one Extremity, will drive out as much at the other, and that instantaneously; or these *Fibres* are solid, and not pervious and some infinitely subtle Spirit pervades them, with as much Facility as it wou'd the most *pervious* Tubes; either of which Suppositions will account for the Appearances, in a gross and general manner, which is all we can pretend to in such conjectural Cases. By the Motion of the *Heart*, through the *Emulgent* Branches, the Blood is brought to the *Kidneys*, and is there freed of its *Serum*, by their  
little

little *Glands*, and is receiv'd into the small *Excretory Ducts* of these *Glands*, to be carried into the *Pelvis*, and thence by proper *Tubes* into the *Bladder*. Much after the same manner, are their proper *Fluids* separated from the *Blood* in the *Liver*, *Sweetbread*, *Testicles*, and the other *Conglobat* and *Conglomerate Glands* of the *Body*, so that it is needless to insist on these.

§ XXXVI. The *Lungs* are compos'd of an infinite number of little *Lobes*, of different *Figures*, and *Magnitudes*, but so join'd as to leave but small *Vacuities* between 'em. Each *Lobe* consists of an infinity of small *spherical* or *oval Vesicles*, form'd by the *Coats* of the small *Branches* of the *Trachea*; so that they may be considered (when blown up) as so many fine *Tubes* ending in little hollow *Spheres* or *Spheroids*; upon the sides of the *Vesicles*, the *Blood Vessels* in a fine *Net-work* are spread. Now before the *fætus* is brought to *Light*, these *Vesicles* lie flat upon one another, and by their *pressure* upon the *Blood Vessels*, hinder its progress thro' them; but as soon as this *fætus* enjoys the benefit of the *Air*, by its weight and *elastick Force*, this *Air* rushes in thro' the *Pipes* of the *Trachea* into these *Vesicles*, and blows 'em up, whereby they stand erect upon the *Trunks* of these little *Wind-pipes*, and give a free passage to the *Blood*

through these Vessels, spread upon their sides. And when by the weight of the *Thorax*, and the Action of the Muscles thereof, with those of the *Abdomen*, and *Midriff*, this *elastick* Fluid is thrust out of the *Vesicles*, thro' the *Trachea* in *Expiration*; these *Vesicles* pressing against one another, and the *elastick* Fluid acting upon the sides of them, and consequently, on the Blood Vessels spread thereon, separate the *Globules* of the Blood, which had Room and Liberty to unite in the wider Channels of the *Veins*; and this separation of these *Globules* of the Blood, from one to another, renders it more capable to *circulate*, in the more narrow passages of the *Capillary* Vessels, divides and subtilises the grosser parts of the *Chyle*, gives a Scarlet Colour, Fluidity and *Energy*, to the gross, grumous and stagnated Venous Blood. But, if I be not very much mistaken, there is still another use of this natural *Function* behind, and that is to form these *elastick Globules* of which the Blood principally consists. It is Matter of Fact and Observation, that the Blood consists of a *Lymph*, which is the common *Vehicle*, several *Salts*, *Ramenta* of a thick consistence, made up of small Particles of carneous and vegetable Fibres from the Food, (which is probably the uniform'd part of the *Chyle*, and Aliment) and these red *Globules*, of which we are now speaking;

king; but sometimes they are of different Colours, as *White*, *Blew* and *Purple*; these any Body may discover with an ordinary *Microscope*. Now it's certain, that these *Globules* may be burst, as in obstructions; or may be all exhausted, as in violent *Hæmorrhages*, and yet be all recovered and recruited again; wherefore it is of necessity, that these *Globules* must be form'd somewhere in the Body from the *Chyle*. And since it's certain that they are not solid *Particles*, both by ocular inspection and touch, and by the necessity they are under to change their Figures into oblong *Spheriods*, in the *capillary Vessels*, as also from their Colour, and that *Acids* do actually destroy their Figures, and coagulate these *Globules*; it is not improbable, they may be little bubbles, blown from the viscid part of the *Chyle*, by the force of some more subtile *Elastick Aura*. Now no Place in the Body, but the *Lungs*, can so conveniently afford this *elastick Fluid*; and this may be the reason why the *Chyle* enters into the *Veins*; and these too only, which are just returning immediately to the Heart, to be sent into the *Lungs*. For since in our gross *Element* of Air, there is constantly lodged, a finer *elastick Fluid*, which is the principal Agent, in all the subtile Effects commonly ascrib'd to the other, tho' the grosser *Element* cannot,

not, yet this finer Fluid, by that vast Force used in *Expiration*, may be thrust in thro' the sides of these *Vesicles*, to the Blood Vessels; and seeing these Blood *Globules* must be generated somewhere, and since there is no part in the Body, this subtile *elastick* Fluid can so conveniently be squeez'd with sufficient force, to get through the sides of the Blood Vessels, but in the *Lungs*; it seems not unlikely, that these *Globules* are form'd there after this manner: The *viscous* part of the *Chyle* being by the shortest and safest course possible, brought into the returning part of the Blood, is sent from the right *Ventricle* of the Heart to the *Lungs*, and is spread upon the sides of the *Vesicles* thereof, in little fine *Tubes*, this fine *elastick* Fluid being squeez'd, in the Act of *Expiration*, through a *Pore*, continued through the *Vesicle* of the *Lungs*, and the side of the Blood Vessels, is forc'd into the *viscous* part of the *Chyle*, which is running by in the *Serum*, and by its *perpendicular pressure* upon the sides of that Cavity it forms, produces a small little *buble*, of a certain magnitude, and thickness of Shell, from whence it has its Colour, and by the force of the succeeding Fluid, this little *buble* is broken off from the *Pore*, and carried along the *Artery*, and the *Cohesion* of the parts of the Shell of this *buble*, being greater than

than the force from without, whereby the thin *Serum* acts upon it, it is preserv'd in its figure in all the various Motions of the compound Fluid of the Blood; and if it happen that these little *bubbles* shou'd be burst, (as they most certainly are by a thousand Causes) when ever they come to the *Lungs*, they are new-form'd again, whereby the *circulation* is rendred constant and uniform. For shou'd these *Globules* be all destroyed, there must of necessity arise a general Obstruction in all the *Capillary Arteries*. The manner of these Production of the little *bubbles*, in the Blood by the *elastick* Fluid, forc'd through the sides of the *Vesicles*, and Blood Vessels in the *Lungs*, is so obvious, that I shall insist no farther upon it, since every body may see an Instance of the same Nature, in mixing Oil with Vinegar, the Substance of which Mixture, when view'd, but with an ordinary *Microscope*, appears to be nothing but an *infinity* of such like little *bubbles*, form'd by the immision of the Air, and Vinegar, into little Shells of Oil. But from this Principle, some of the despair'd of Appearances, in the *Animal Oeconomy*, may be made easy; and some difficulties about the Causes of Diseases, and the manner of the Operation of *Medicines* vanish. And this makes it look the more like truth, Nature being frugal in her Principles, but

various in the Effects thence arising. But it being both foreign to my Design, and unfit for the Limits I have prescrib'd to my self, to deduce *Corollaries* arising from a Conjecture only: I shall therefore proceed to represent some others of the Animal *Organs* and *Functions*, in the best manner I am able.

§ XXXVII. A *Muscle* is a bundle of *Vesicular Threads*, or of solid *Filaments*, involved in one common *Membrane*, one of whose *Extremities* is fastned to an *Immoveable*, the other to a *moveable* part of the *Body*; which by the inflation of the *Vesicles*, or swelling and hardening of these *Filaments*, are brought nearer one another and so become the proper *Organs* of Motion. When a *Muscle* by boiling, washing, and cleansing, is duly prepar'd the Texture of these *Vesicular Threads*, or solid *Filaments* become more evident and perspicuous. If the last *Fibres* of *Muscles* be *Vesicular*, then probably they may not be unlike a string of *hollow Beads*, and may be originally hollow *Tubes*, straitly ty'd together, by transverse *Filaments*, so as to form these little *Bladders*; with which small *Branches* of *Blood Vessels* are so interwoven, as that the Mouth of a little *Artery*, and *Nerve*, gapes into the *Cavity* of these *Vesicles*: Both which are so absolutely necessary to the *Action* of a *Muscle*.

cle, that either being tyed or cut, at the entry of it, no Action or Motion can ensue.

If *Muscular Fibrils*, be *Vascular*, then we may reasonably suppose all the *Carneous Fibres*, which are necessarily requir'd for Motion, to be *Vesicular*, after the manner I have now described them; and that the *Nervous Fibres*, are *Cylindrical Tubes*, for conveying the *Nervous Juices*. The two *Extremities* of the *Muscle* which are called *Tendinous*, were generally thought, to be the ends of the *Carneous Fibres* more closely compacted, so as to admit but few *Blood Vessels* or *Nervous Channels*. But Mr. *Leuwenboeck*, by his latter Observations on them, seems to think them of a different Substance from, and to be discontinued with, the *Belly* or fleshy part of the *Muscle*. If the *Muscular Fibrils* be *Vascular* (as I have said) then the use of their *Vesicular Cells*, may be for receiving the *Arterial* and *Nervous Juices*, that by their Action upon one another, they may be swell'd some how, so as to shorten the Length of every *Fibril*, and consequently to bring the *Extremities* of the *Muscle* near one another, which is the proper Action of the *Muscle*. But whether the swelling of the *Vesicles* be owing to an *Explosion*; to an instantaneous *Fermentation*; to the greater *Attraction* of the *Nervous Fluid*

on

on the Blood Globules, than those have upon one another; or to the mere *Mechanical* Action and Pressure, of the Nervous Juice on the arterial Blood already filling the *Vesicule*. Or lastly, whether the *Fibrils* are not in themselves solid, (and not Tubular Filaments,) contracted by a subtile Spirit pervading their solid Parts, whose *Law* and *Action*, is, or is never to be determin'd, I will not take upon me to decide. But if I conjecture right, the Nature of *Life*, *Light*, and *Animal Motion*, will be an eternal Reproach, to *Mechanism* and Humane Invention. The surest Method to arrive at any certainty, in such intricate and obscure Subjects, as some of those Animal *Functions* are, is to go no further than *Anatomy* and *Ocular* Inspection will direct us; and since it is not as yet positively Demonstrated, whether the *Animal Spirits*, be a Fluid contain'd in the *Nervous* and *Membranous* Fibrils, as hollow Tubes, or if they are only a *subtile Spirit* or *Aura* pervading these, as solid Filaments. Nor whether the last and final-*est* Muscular Fibres be *Vesicular*, or not, I cannot see sufficient materials, to found any just Explication of this Animal Function, upon.

§ XXXVIII. The Fluids of the Body are principally propell'd, by the Action of the Heart, and the *elastick* Force of the *Fibres* of

of the containing Vessels. Now the Heart is a *Muscle*, like other *Muscles*, consisting of several Orders of fleshy *Fibres*, of different Directions, it has two little *Ears* and as many *Ventricles*, which are Cavities for receiving or holding the Blood, as it comes from the several Vessels, or is to be driven to different Places. The *Fibres* of this *Muscle*, act as those of other *Muscles* may be suppos'd to do, for by the winding and spiral Direction of its several Orders of *Fibres*, the Cavities of the *Ears* and *Ventricles* are lessen'd or constring'd. And it is observable that all the *Muscular Fibres* of the Coats of the Vessels, act after a different manner from the Nervous or *Membranous* Coats, the first seem to act by the assistance of some foreign Fluid, *Spirit*, or Principle. But the *Membranous* Coats, meerly by their own *Elasticity*, being stretch'd first by external Violence. Thus the sides of all *Membranes* are bent or press'd outward by some included Fluid, but restore themselves by their own natural *Elasticity*; whereas whenever a Coat consists of *Fibres* of whatever kind, excepting those for *Sensation* or *Nutrition*, it is a sure *Indication* that this Coat acts as a *Muscle*; for Nature does nothing in vain, and wou'd never have distinguish'd a Coat into *Fibres*, but for *Muscular* Action, when a continued *Membranous*,

nous, or *Tendinous* one, is more capable of acting by its own *Elasticity*. So that the Nature of the Coats, and of their constituent *Fibres*, of the Channels, being known, together with the Range and Direction of these *Fibres*, it is easy to know the manner of their operating upon the included Fluid. The Coats of the *Gullet* are three, the outermost *Membranous*, the second fleshy and *Muscular*, turning obliquely from the uppermost end of the *Oesophagus* to the *Stomach*; the third, is tendinous and *muscular*, of white slender *Fibres* diversely interwoven. The *Stomach* has four Coats, the innermost is Carpet-like, of white short tendinous *Fibres* standing *perpendicular* upon the next Coat, which is *nervous* and extremely sensible; the third is fleshy and *Muscular*, of straight and circular *Fibres*; the fourth *Membranous* from the *Peritonæum*. The *Guts* consist of three Coats, the innermost is of the same nature with that of the innermost of the *Stomach*, the second is of two Orders of *Muscular Fibres*, *Longitudinal* and *Spiral*, the third is common and *membranous*, arising likewise from the *Peritonæum*. The *Nerves*, as I have before said, are a bundle of fine, small, and slender *Pipes*, or *Threads*, wherein the Animal Spirits, or something Analogous to what is called by that Name, are treasur'd up for the Expences of Motion and  
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*Sensation*; they arise from the *Glands* of the *cineritious* part of the Brain, and are terminated in all the points of the Body; ten pair descend immediately through proper Holes of the *Skull*, and serve the adjacent Parts, and particularly the *Organs* of four of the Senses; the rest in a large bundle, are let down by the Cavity of the *Vertebra*, and at fit Places are sent forth to actuate the several inferior parts of the Body. The *Arteries* have three Coats, the outermost is a fine Web of *Nerves*, and Blood Vessels, for the nourishment of these other Coats, and for the *Muscular Action* of the intermediate one, which is made up of several *strata* of *Spiral Muscular Fibres*, according to the bigness of the *Artery*. The third is a close transparent *Membrane* very strong and compact, to keep in the Blood which otherwise upon the dilatation of the *Artery*, wou'd tear the *Muscular Fibres* asunder. The *Veins* have the same Coats with the *Arteries*, only the *Muscular Spiral Fibres* are thinner, because of the lesser force of the Blood against the sides of the diverging *Veins*, than those of the converging *Arteries*. From this general account of the structure of the *Vessels*, their Actions upon the inclosed Fluid may be easily understood, the short erected *Fibres* serve for the attrition of the *Aliment*, and for straitning the Cavity of the *Guts*  
and

and *Stomach*; the *oblique Fibres*, which make but few turns serve to propagate gently the included Fluid, the *Longitudinal* ones to move the Vessel, and the included Fluid, up or down in a direction *parallel* to its length, by encreasing this dimension and thereby lessening the other, *i. e.* the transverse *Diameter*; the *Spiral* ones by squeezing it transversely, and so encreasing it in length or lessening it in breadth. Thus the Blood being pusht by the contraction of the Heart into the *Arteries*, distends their Coats along their whole length, 'till the force of the natural *Elasticity* of the *Membranous Coat*, be equal to the force of this Impulse; then that *Elasticity* of this Coat beginning to act, at the same time the *nervous Juice*, or Spirit is deriv'd through the *Nerves* by this dilatation of the small *Arteries*, among the *Originating Nerves* in the Brain, and so brings the *Muscular Fibres* into Action. And both these Forces acting at once, propel the Blood in a continued Stream, through the uninterrupted Channels of the *Veins* and *Arteries*. And the impulse of the Heart, propagated only by the *Membranous Coat*, is that which when felt, is call'd a *Pulse* or *Pulsation* of the *Artery*.

§ XXXIX. All *Sensation* is perform'd by the immediate Action of the finer and more fluid parts of Bodies, upon the *Organs* of Sense;

Sense; the Impulse communicated by these subtile parts of Bodies, upon the *Organs* fitly disposed, is through them transmitted to the *Nerves*, appropriated and contriv'd for such a Sense, and through them to the Brain. Thus in *Vision*, the *Light* reflected from the Surfaces of Bodies, is transmitted thro' the *Humours* of the Eye, and congregated upon the *Retina*, in the same manner it was reflected from the Body, and thereby an Impulse modified after a certain manner, strikes the *Filaments* of the *Optick Nerves*, which convey this Impulse to the Brain. In *Hearing*, the Sound after diverse Modifications, in its passage through the *Meatus Auditorius*, strikes on the *tympanum*, which moving the Bones of the Barrel, and they the inclosed Air of the *Labyrinth*, the *Auditory Nerves* there, are mov'd, after the same manner they wou'd have been, had the common Air acted upon them, with the Advantage of a better qualified and gentler Impulse than they cou'd have had otherwise. In *Smelling*, *Tasting*, and *Toucing*, the *Effluvia* and more subtile parts of Bodies, act immediately upon the *Nerves* themselves, and they communicate this Action to the Brain: So that in some manner, all *Sensation* is nothing but *Toucing*, several ways diversified. *Generation* is nothing but *Accretion*, for it is beyond all doubt, that  
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all *Generation* is from a preceding little *Animal* lodged in the Male. I have demonstrated the *Mechanical* production of *Animals*, to be impossible and unconceivable; there is nothing in an *Animal* but an *infinity* of branching and winding Channels, and their contain'd Fluids, and no Disposition or Arrangement of either, can produce an *Animal*, since all the parts must be form'd together, in order to make a complete *Animalcul*; for it is not in *Animals*, as in Houses, or other humane Performances, where the parts can subsist separately and be fram'd one after another; but towards an *Animal*, the whole *integral* parts at least, must have been form'd at once: Since we are very sensible there is not one *noble* Part, that an *Animal* can be without, but with the immediate danger of the whole Compound. And to have the *Animal* compleat and perfect in its kind, there is not a single Vessel, or *Organ*, how inconsiderable soever, that must not have been compleatly formed and fitted up, all and sundry, at one and the same instant of time, since the Circulation of the Fluids, and the natural Functions of the whole, do in a higher or lower degree, depend on the Integrity and Perfection of each single part. We find some little *bubbles*, or Blood *Globules*, may be form'd out of the *Chyle* in  
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the Vessels, and one kind of Liquor may be separated from another, out of the Blood in the *Glands*, and these are all the Productions an *Animal* is capable of, which can never reach to that wonderful Number, and Disposition of parts, an *Animal* consists of. Now, since there is no necessity to think *God Almighty* is confin'd to a new Creation, in ev'ry *Generation* of an *Animal*, and that these *Animals* themselves are conspicuous in all Male Seeds hitherto examin'd, it is plain that they must have been all created at once; and lodg'd in the Loyns of the Original pairs of all the *Species* of *Animals*. Likewise the Fluids, if they did not move in the Channels of these small *Animals*, wou'd corrupt and destroy their containing Vessels. It's evident then that they must *circulate* after a manner proper to themselves; tho' doubtless the *Velocity* of their Motions is perfectly accommodated to the smallness of their *Bulk*, and the slenderness of their solid parts; we see an Image of this slow and low kind of Life in *Swallows*, *Insects*, *Vipers*, and other *Reptiles* in the Winter, and in almost all younger *Species* of *Animals*, and even in adult *Animals* of the rational kind, a Nervous Distemper has continued them long alive, in a kind of a *Lethargick*, *Drowsiness* without Food or Motion, and without the common Expences of Life.

But since these Fluids cannot move, without some small insensible *Evacuations* and *Secretions*, this Loss must be repair'd some way or other. Wherefore, it is not improbable they may lurk somewhere in the Male, in some proper Place, 'till they be fit to be carried off in the soft and tender Fluid of the *Semen*, to be afterwards lodg'd in the Female; where they are fitted with Accommodations, suited to this Degree of Growth and Perfection, 'till they arrive to the next Period of their Lives; *viz.* to bear the *Light* and the *Air*. We are certain that the *Seeds* of *Plants* are nothing but little *Plants*, perfectly form'd, with Branches and Leaves duly folded up, and involv'd in *Membranes*, or surrounded with *Walls* proper to defend them in this tender Estate, from external Injuries; that the manner of the *Generation* of *Vegetables*, is perfectly *Analogous* and *Consonant* (as far as their different Natures and Circumstances will permit) to this proposed manner of the *Generation* of *Animals*. And that *Vegetation* is only the unfolding and extending of these Branches and Leaves, by the Force of Juices rais'd by Heat, in the slender *Tubes* of the *Plant*. We know that the Eggs of *Animals* are only an *Uterus* for a little *Animal*, furnished with proper Food, and fenc'd from external Injuries; and we know likewise that

that all the Effects of *incubation*, is supplying a fit degree of Heat and Warmth, to make the congeal'd Fluids flow, and more easily pass into the nourishing Channels of the included *Animalcul*; and the Heat of the *Sun* or of our *Culinary* Fires, when duly adjusted, produce the same very Effects with that of the *Females*. We are sure, that all the several *Transformations* of *Insects* and other *Animals*, are nothing but the *Expansion* of their parts, and the breaking of the *Membranes* that folded 'em up, by the *Augmentation* of these parts; that all the several *Figures* and *Shapes* they put on, are owing to the several *Membranes* they are involv'd in. Now were there no other Argument, but the *Analogy* between the manner of the *Generation* and *Transformations* of these lower, and of the more noble *Animals*, it were sufficient to persuade any one, who considers the simplicity and uniformity of Nature in all her Works. But this, with these already mentioned, make it highly probable that we are all deriv'd from one *Seed*, and were once all actually in the Loyns of our first Parent, and have been ever since, growing to our present Estate.

§ XL. From this general view of the *Structure* of the parts, and of the manner how the *Animal Functions* are perform'd, ev'ry body may see how *wonderfully we are*

made, how wisely our several parts are fitted for their uses; how justly our Fluids are contriv'd and dispos'd, to make these un-interrupted *Circulations* wherein Life consists; how simple, and yet how sufficient, the Causes of all those various Motions, (which we are in some manner able to discover) the *Animal* performs, are. It is impossible duly to consider these things without being rapt into admiration of the infinite *Wisdom* of the *Divine Architect*, and contemning the arrogant Pretences of the *World* and *Animal Wrights*, and much more the Productions of Chance or juggling *Atoms*; for since even *Mechanism*, assisted by some kind of *Art* and *Contrivance*, does so miserably blunder in the Undertakings of this Nature (as we may see in all the *Schemes* of the *Projectors* upon these Heads) we may be assured *blind Chance* and *Fumble* cou'd never produce so beautiful simple and uniform Effects. Cou'd any of our *mechanical* Undertakers, with all their skill and cunning, make but an *Insect* or a *Plant*, with the same Faculties and Qualities that Nature does; we shou'd begin to hearken to 'em. But they are so far from that, that the most exact and nice Performances of *Art*, come so far short of the dead *Organs* of *Animals*, or the *inanimate* Productions of Nature, that a weak Eye may discover the vast

vast Difference, Wherefore of unavoidable Necessity, *He that form'd the Eye must himself see, and he that made the Ear must himself hear, and he that endu'd Man with Wisdom must himself understand;* and he that contriv'd so wonderfully and wisely, and form'd so justly and exactly, all things both animate and inanimate, must needs *Himself be.*

But I proceed to make some reflections upon the particular Instances of *Counsel* and *Wisdom* in the *Animal* Fabrick.

§ XLI. The Skin with its parts is what offers it self first; the *Scarfskin* being uppermost, is compos'd of several Lays of small *Scales*, which cover one another more or less, or lie thicker, according as it is thicker in one part of the Body than another; between these *Scales* the *Excretory* Ducts of the *Miliary Glands* of the true Skin open. *Lewenboeck* reckons that about one *Cuticular Scale*, 500 such Ducts may lie, and that a Grain of Sand will cover 250 of these *Scales*, so that one grain of Sand will cover 125000 *Orifices* of these *Excretory* Ducts. Now what a prodigious Number of such *Glands* must there be on the Surface of the whole Body! Into ev'ry one of these *Glands* an *Artery*, *Vein* and *Nerve* do enter; so that we may guess how prodigious the Number of *Organs* in an *Animal* Body must be, from

these that are visible to the Eye assisted with an ordinary *Microscope*. These *Glands* seern the Sweat and insensible Perspiration. And of necessity they must be many, since *Sanctorius* observes, that through them fifteen Ounces weight of a Fluid passes in 24 Hours. Next under the *Scarfskin* are the *Papillæ Pyramidales*, infinite likewise in Number; they are the Extremities of the *Nerves* of the *Skin*, and serve more immediately for the Sense of *Feeling*, to convey the Impulse receiv'd, along the *Nerves* to the *Brain*. About these, the *Nerves* and other Vessels make a fine *Web*, all cover'd over with a mucous Substance, to moisten these *Papillæ Pyramidales*; and then under this the *Miliary Glands* themselves are plac'd, protruding their *Secretory Ducts*, to the Surface of the *Scarfskin*; upon which there are many *parallel Lines*, and these intersected by others, and in each intersection a Hair is planted. In the *Summer* the *Skin* is thinner and softer, in *Winter* more compact and hard, by reason of the heat and cold of these different Seasons. The *Scales* of which the *Scarfskin* is compos'd are design'd to fence the *Orifices* of the *Secretory Ducts* of the *Miliary Glands*, and to hinder Objects from making too painful and exquisite an Impression on the *Nerves*, and to skreen them from external Injuries; the *Skin* it self is design'd to wrap up the whole

whole Body, to sustain and to keep the *Papillæ Pyramidales* in their Places, and the *Miliary Glands* from being disordered, to receive the Impressions of external Objects, and to be the *Organ* of the Sense of *Tou-cking* and *Feeling*. Now what can be more wonderfully contriv'd than this exterior part? If the *Papillæ Piramidales* or the *Miliary Glands* had been few and large, then the *Intervals* had been without any Sense of *Feeling*, and so might have been destroy'd without our Knowledge, to the danger of the whole; and these *Intervals* had not been freed from the noxious parts, which are here thrown out of the Body by these *Glands*; but by their infinite Number, ev'ry point and *Atom* of the *Animal Body* is taken care of. But that which is yet most wonderful, is the apt proportioning this Sense of *Feeling*, to the Actions and Impulses of the Bodies among which we live. For had our Sense of *Feeling* been ten or twenty times as exquisite as it is, then we shou'd have been in perpetual Torment, ev'ry Hair had been a Dagger, the touch of a Feather, or of the Wing of a Fly, had made us cry out, we shou'd not have dar'd to have approach'd our Cloaths or our Beds; in short, we had liv'd in perpetual Misery; and had it been as many times duller, or more *callous* than it is, our tenderest parts

had been as insensible as our Hairs or Nails, and might have been torn away or consum'd, without our Knowledge or Concern. Whereas by this nice adjustment of the Sense of *Feeling* to the Impulses and Actions of Bodies round us, we can live in indolence from the Disturbance of the *effluvia*, and Actions of little Bodies that are necessarily in Motion; and we feel sensibly enough, to hinder us from hazarding the Ruin of our Fabrick. And universally indeed in all *Animals* whatsoever, this Sense is adapted to the Circumstances wherein they live, which is a notable Instance of *Council* and *Design* in the formation of the Parts. And it is worth noticing, that this Sense of *Feeling* is rendred more exquisite and sensible, or more dull and imperceptible, as it is more or less used; for it is highly probable, that the *Scales* which compose the *Scarfskin*, and guard the *Organs* of this Sense from being violated, do arise from the *pressure* of touching Bodies upon the Mouths of the *Superficial* Vessels at different times, by which some drops of a viscid Fluid is forc'd out, which there drying and hardning, become a small *Scale*; and therefore the oftner the Mouths of these Vessels are press'd upon, or the oftner we use the *Organs* of *Touching*, the more of these *Scales* are form'd, and the Skin becomes the thicker, and so a *cal-*  
*lousness*

*lousness* grows upon it. And consequently, the more moderately we use the Pleasures of Sense the more lively and sensible they are, and the more immoderately we use these Pleasures, the less they are so; which is a wonderful wise Contrivance of the *Author* of *Nature*; for were it otherwise, so distracted is the most part of Mankind, that they wou'd certainly destroy themselves, since we see where there is both Sin and present Punishment, they are not kept from Excesses that way.

§ XLII. Having already shewn the wonderful yet simple structure of the *Muscles*, I have little more to add upon that Head. For tho' ev'ry single *Muscle*, of which there are about 446 in a Humane Body, either in its *Figure*, *Situation* or *Insertion*, has something that speaks *Design* and *Council*; yet seeing *Borelli* has written a whole Book to shew this, and to instance in all the Particulars, were to transcribe it, or to write a whole *System* of *Myologie*, I shall refer my Reader for his full Satisfaction in this Affair, to that learned and surprising Book *De motu Animalium*, and shall only suggest a few Instances. 1. Then the manner of the Disposition of the *Muscles* of the *Fingers* and *Toes*, is admirable. We know that for the uses of Life, these

*Muscles*.

*Muscles* were to be strong and large, that that they might be sufficient for the various, and forceable Motions of these *Organs*; now had they been situated near or about these Parts, they wou'd have altogether disturb'd their Motions, and made these Places soft and spongy, and consequently unfit for grasping and going: And to avoid this, the *Infinitely wise Author of Nature*, has plac'd them at a considerable distance from these *Organs*; and that ev'n there, they might not in bending the *Arm* or *Leg*, rise up and fill those Places with their *Bodies* or *Tendons*, he has ty'd them to the Bones by *Annular Ligaments*; and also that one *Tendon* might not be interrupted in its Course by another, he has slit some, that others might pass through them undisturb'd. This is such a wonderful Instance of Wisdom and Design, that none can pass it over without Admiration. 2. It is very observable that in *Muscular Motion* the Expense of *Animal Spirits*, is not in Proportion to the Labour the *Animal* is at. Mr. *Bernoulli* in that *curious Meditation* about *Muscular Motion*, printed in the *Acta Lipsie* 1694, has demonstrated (for whatever be in his *Theory*, yet there is certainty enough in his general Construction of a Muscle, to bear out this Observation) that the Expenses of *Animal Spirits*, are in a much less Proportion,

tion, than the elevated Weights; for supposing the *Animal Spirits* expended, to be as 8, then a Weight four times as great, as when they are but as 5, may be lifted. So that when the *Animal Spirits* are but as 5 to 8, the Weight sustain'd by 'em shall be as 1 to 4. And the like of the other Proportions of the *Animal Spirits*; especially the Difference becomes most sensible between these *Animal Spirits* and the sustain'd Weights, when these *Spirits* are expanded in greatest Quantities. Now what a wonderful wise Contrivance and *Compendium* of Nature is this? Here in great Labour, the *Animal Spirits* which are the Life of the Blood, *which is it self the Life of the Animal*, are sav'd as much as is possible; so that a Man who is obliged to hard Labour, is not reduc'd to the necessity of having twice or four times as much Victuals, as one that is under no necessity to Work. We all know that the *Spirits* are the most precious things in all the *Animal Body*, by which we move, and our Blood *circulates*, *i. e.* we live; by which all the Pleasures of Life are relished, and all *Sensation* perform'd, by which we have that Liveliness and Agility, that Chearfulness and Tranquility, that actuates all our Enjoyments; and without which, we are languid, and dull, unactive, and thoughtless. Now this, fo

so necessary and useful a Substance, was to be fav'd by all means possible, and agreeable to the necessities of Life, and we see the wise Author of Nature, has taken wonderful Care, that no Expences shou'd be made therein that cou'd be avoided. 3. What a strange variety of Motions are our *Organs* capable of? There is no possible one, that might be useful to us that we want, and how wonderfully is the whole *Machin* adjusted? For our erect Motion, the Center of Gravity is so dispos'd, as to fall, by a Line drawn from it to the Center of the *Earth*, always in some part of the *parallelogram* form'd by the outer sides of our Feet, and two Lines drawn by our Toes and Heels, by which means we are kept from tumbling: And if at any time we chance to throw this Line without that Space, and so be in hazard of falling, our Arms, and the various Motions of our Head, and Breast, immediately bring it back within that Space. Those *Animals* that are design'd for flying or swimming on the Surface of the Water, have all their strongest *Muscles* upon their Breasts, whereby they are kept in the fittest Posture for swimming or flying, the *Center of Gravity* being so disposed as they are thereby enabled very easily, to keep their Heads above Water. And in those *Animals* that live within the Surface of the Waters, there

there is a Bladder fill'd with Air, which has a *Duct* open to the outward Air on the Surface of the Water, whose *Orifice* is endow'd with a *Muscular Sphincter*, by which they let out and take in the *Air*, to render them *Specifically* lighter or heavier, than the Fluid they swim in, and so sink or emerge as their Occasions prompt them, or as they pass to a *Specifical* lighter or heavier *Element*; for by taking in more *Air*, they become lighter than they were, and so necessarily emerge, and by letting out some, they become heavier, and so sink. And it has been observed that Fishes have got up to the Surface of the Water meerly to change and alter the *Specifick Gravity* of this *Air*. And this Bladder is commonly full of *Air*, which is under some Degree of Condensation, from the *pressure* of the *Muscular* sides thereof; such to wit, as renders them in an *Equilibrium* without any Pain, with that kind of Fluid they live most in, and they commonly alter their *Equilibrium*, by the Compression or Expansion of this Bladder, which being cut out, the Fish ever after, either swims on the Surface or sinks to the Bottom. Birds and Fowls that sleep, resting on one Foot to ease the other, naturally lay their Heads under their Wings, that so the *Center* of the *Gravity* of their whole Body, may fall upon the Foot they

they stand on, and the *Animal* be preserv'd from overturning; and those Fowls that sleep so on the small Branches of Trees, incline a little backwards, that their Claws by the *Gravity* of their Body, without any *Muscular* Contraction, may grasp the Branch more strongly. These are wonderful Instances of *Divine Wisdom* and *Providence*; but those who please to consult that noble Work of *Borelli's*, will find to their Satisfaction, a thousand such Instances, relating to this Head alone of *Muscular* Motion.

§ XLIII. The Bones consist of hard compacted *Fibres*, ty'd together by *Transverse* ones, after the manner of the *Muscles*; they are nourished by Blood Vessels which enter their Substance at several Places, which upon the compleat Growth of these *Bones*, are so straightned as to admit only what is sufficient to repair their Decays. All the considerably thick *Bones* are either hollow or spongy, and both sorts contain an *oleaginous* Substance, preserv'd in little *Vesicles*, which by the Heat of the Body, is exhal'd through the porous Substance of these *Bones*, to supple and anoint their *Fibres*, that they dry not, and thereby grow brittle. All the *Bones* are cover'd with a very sensible *Membrane* call'd the *Periosteum*, each large *Bone*, is considerably bigger at the Extremities than at the middle, and that for ve-  
ry

ry wise Ends and Purposes: For 1. Thereby the *Articulations* are made stronger, for had they been lesser or equal to the middle, our Limbs had been in hazard of being disjointed upon ev'ry Occasion. And 2. By the largeness of these *Tubercles*, it comes to pass, that in all the *Revolution* of the joint. The *Tendon* is kept at the same distance of the *Semidiameter* of the *Tubercle* from the Center thereof, *i. e.* the Center of Motion; whereby, in the *Articulations* of the Shoulder and Knee especially, the Arm and Leg, is capable of moving round, more than a *Semicircle* which by no other Contrivance possible, but this cou'd be obtain'd. There are several and various manners of *Articulations* of the *Bones* into one another, wonderfully fitted for the Motions of the several Members, one is like *Ball* and *Socket*, by which the *Bone* can move equally any way; as the *Thigh-Bone* with the *Ischium*; others are by way of *Charnal*, as the *Radius* with the *Ulna*; a third are only ty'd together by intervening *Cartilages*, as the *Vertebrae* of the Back. Now all these different *Articulations* are from the Necessity of the *Situation*, or Motion of these *Bones*. The *Bones* in order to be the most convenient that might be, ought to have been as light, as was reconcileable with a sufficient degree of Strength, that the Instruments

ments of Motion, might not require too great an Expense of Spirits, to move them, and that the *mechanical Machin* might not become a Burthen to themselves; now the wise *Author of Nature*, has wonderfully provided for this, for he has made 'em light, by evacuating their middle Substance, and yet they are stronger by very far, than if they had compos'd one solid *Cylinder*; for *Galileo* has demonstrated, that of two *Bones* of equal lengths, and of equal Number of *Fibres*; the Strength of the one is the Strength of the other, as their *Diameters* are; so that a hollow *Bone* of a double *Diameter*, to a close one of the same Number of *Fibres*, is as 2 to 1, or the first is twice as strong as the second. This is most conspicuous in those *Animals* that are form'd to fly; it is wonderful, how light and yet how strong, the Quills of their Feathers and their *Bones* are, and this wonderful wise *End*, cou'd no otherways be obtain'd but by this Contrivance. *Borelli* hath shewn that these *Bones* are so many *Vécles*, of which the Center of the *Articulation* is the *Fulcrum*, the *Tendons* are the *Ropes*, by which the *Vires Motiva* of the *Muscles* elevate, and move any weight, or overcome any Resistance. There is a wonderful, and exactly nice *Geometry* used by Nature in the Figure, Connexion, Order, and Motions of these  
Pillars.

*Pillars* of the Body, and of their Cover the *Muscles*; it were alone a sufficient Work, to shew all the *Necessities*, the wise *Contrivances*, and prudent *adaptions* of these admirable *Machines* for the benefit of the whole. I shall Instance only in two or three Particulars, and then proceed. I. Then, what can be more wonderfully contriv'd than the *Back-bone*; had it been all of one entire *Bone*, without *Articulations*, we cou'd not have stoop'd or turn'd, but have gone forward like a Post or Pillar; had it been compos'd of a few *Bones* only, then the *Articulations* of these *Bones* in bending our Backs, must have made a large *Angle* upon their innermost edges, and so the *Spinal Marrow*, which sends *Nerves* to all the inferior parts of the Body, had been in hazard of being bruis'd at every stooping; and consequently all the inferior Parts, had been in perpetual hazard of being depriv'd of the Instruments of their Motions; besides that the whole wou'd not have been pliable, for the various Postures we have occasion to put our selves in. If it had consisted of various *Bones* without intervening *Cartilages*, we shou'd have had no more Benefit by it, than if it had been entire without *Articulations*, or had these *Articulations* been after the manner of some others of the *Bones*, we had not been capable of these Varieties of Motions that we now are, if each *Vertebra* had had its own proper *Cartilage*, the

Z Articu-

*Articulations* might have been easily disjointed. So that we see, the Contrivance of this Hulk as it were, of the Body is the best that can be imagin'd; for by these many and small *Articulations* upon somewhat plain and smooth Surfaces, ty'd by a common *Cartilage*, the Back, for the Security of that *Medullary Substance*, that runs down its *Cavity*, is bent after the manner of the *Catenarian Curve*, by which it obtains that *Curvature* that is safest for the included *Marrow*, and brings the greatest degree of firmness; the oblique *Processes* of each Superior and Inferior *Vertebra*, keeping the middle, from being thrust backwards or forwards, to hurt the *Spinal Marrow*. Besides, had not the *Transverse Processes* been so plac'd as they are, to keep the intermediate *Vertebra* from being thrust backward or forward, then there wou'd have been no more reason why in *Inspiration*, the *Ribs* shou'd have mov'd upwards and forwards, than backwards. But as they are now contriv'd, these *Processes* force the *Ribs* to move upwards, and so lift up the *Sternum*, whence the *dilatation* of the *Thorax* proceeds, which cou'd not *dilate*, were there no *Transverse Processes*, or they otherwise dispos'd. Now can there be a more manifest Instance of Council and Contrivance than this. Certainly, if infinite Wisdom were suppos'd to have fram'd this part, it cou'd not have given a more pregnant Indication thereof.

2. As I have observ'd before, some *Bones* are articulated after the manner of *Ball and Socket*, as the *Humerus* with the *Scapula*, and that for this wise End, that the Arm might have all manner of possible Motions; but the *Ulna* and *Cubitus* is join'd by way of *Charnal*, that this *Articulation* might be the more strong, for had it been after the former manner, we shou'd have had no Benefit thereby, for that *Articulation* of the Shoulder, takes off the Necessity of another such here; the Hand by it, having all the Motions, that it cou'd have by another of the same kind, in this other *Articulation*; and we shou'd have lost the Benefit of the greater Strength in this Joint. Thus we see, Nature in these Motions looses no Benefit in the several Parts, that can consist with the good of the whole. 3. Because the *Tubercles* of the *Bones* of the *Fingers* and *Toes*, cou'd not be conveniently so large in Proportion to the middle of these *Bones* as they are in others, because thereby in grasping or squeezing, these points of the *Fingers* which are at the *Articulations*, cou'd only come into *contact* with the Body squeez'd, and so the Action cou'd not be uniform; and by this smalness of these *Tubercles*, there was a hazard of bringing the direction of the Action of the *Tendons* of those *Muscles*, which contract the *Finger* and *Toes*, quite through, or very near the *Center of Motion*; whereby this Action wou'd have been

quite, or almost destroy'd. Now to prevent this Inconvenience, the *Ossa Sesamoidæa* (call'd so from their Resemblance to the Grains of *Sesamum*) are plac'd at the *Articulations* of these *Bones*, to serve as so many *Pullies*, about which the *Tendons* pass, at some distance from the Center of the *Articulation*, whereby the direction of the Motion of these *Tendons*, are remov'd always at the same distance from the Center of Motion, of the *Articulation*. The same Artifice is us'd in the *Knee*, by means of the *Patella*; these are wise and noble Ends, which the Wit of Men cou'd not have thought of, had they not observ'd them.

§ XLIV. How wonderfully is the Brain contriv'd, how carefully and strongly is that principal *Organ* of the Body, fenc'd from external Injuries, by a thick Wall of hard *Bone*, and two very close and compact *Membranes*? What an infinite Multitude of *Glands*, are in the *Cortical* part, and of beginning *Nerves* in the *Medullar* Part, a Hundred of which do not exceed one single Hair? How commodiously are the *Nerves*, that serve for four of the *Senses*, and all the parts of the *Superior Regions*, sent out the shortest and safest ways through proper Holes in the Head? And those that serve the *Inferior Regions* of the Body, carry'd down in a *Bony Channel*. And it is very remarkable, that the *Veins* do not pass out, at the same Holes the *Arteries* enter; for if they

they did, then upon any violent Motion of the Blood, or any greater Quantity thereof than ordinary, lodg'd in the *Arteries*, their *dilatation* and *pulsation* wou'd compress the *Veins* against the *bony* sides of their Passage, and so occasion a *stagnation* and *extravasation* of the Blood in the Brain, to the destruction of the whole *Machin*; which by these different *Enteries* and *Exits* of these Vessels is prevented. These *Veins* also do not run along by the sides of the *Arteries* in the Brain, as they do thro' all the rest of the Body, which is also another wise Contrivance of Nature; for the *Arteries* here, were by their *dilatation* to press out their Juice or Spirit from the *Nerves*, into the *Muscles* of *involuntary* Motion, which wou'd have been hindred if the *Veins* had always gone along with the *Arteries*; for these *Veins* wou'd have receiv'd the impulse of the *Arteries*, and thereby in some Measure kept it from the *Nerves*. Next how strongly is the *Heart* built, and with what a force does it squeeze out the Blood into the *Arteries*; *Borelli* reckons it equal to the force of 3000 Pound Weight, and that 350 Pound Weight of Blood, passes through the *Heart* ev'ry Hour. How variously and effectually for its end, are its *muscular Fibres* arrang'd, and with what Judgment are its *Columns* and *Furrows* dispos'd, for the closer Contraction of its *Ventricles*! its point is turn'd a little toward the left side, for the more easy

ascent of the reflux Blood in the *Cava*, for  
 thereby like a reclining inverted *Siphon*, the  
 left *Auricle* becomes lower than the right. All  
 the *Auricles* and *Ventricles* have *Valves*, where-  
 by the Blood has a passage in its true course  
 forward, but is hindred from returning the  
 same way; which wou'd frequently happen,  
 upon the equal *pressure* of the Blood on all  
 Hands, and the Resistance of the sides of the  
 Vessels, to the Ruin of the *Animal*; which  
 Inconvenience is entirely prevented, by this  
 prudent Contrivance and Situation of the *Valves*.  
 And ev'n the Figure of the *Valves* themselves,  
 in the several different Places, is for wise Ends  
 and Purposes. But that which is most won-  
 derful in this Affair, is the different *Structure*  
 of the *Heart* in the *Fœtus*, from that of the  
 same in adult Persons. In the *Heart* of the  
*Fœtus*, just opposite to the Mouth of the *Ca-  
 va ascendens*, there is a Hole from the *Cava*,  
 that opens into the *Vena Pulmonalis*, and is  
 call'd the *Foramen Ovale*; there is likewise a  
 Passage, which runs from the *Trunk* of the  
*Aorta*, to the *Trunk* of *Arteria Pulmonalis*.  
 Now the Blood which is receiv'd by the *Pla-  
 centa* from the Mother, is by the *umbilical  
 Veins* carried into the *Porta*, from which it is  
 sent to the *Cava*, by a Canal which goes strait  
 from the *Trunk* of the one, to the *Trunk* of the  
 other, by the *Cava* it is thrown through the  
*foramen Ovale*, into the *Vena Pulmonalis*, which  
 carries

carries it to the left *Ventricle* of the *Heart*, by which it is squeez'd into the *Aorta*, to be dispers'd over the *Body*. The *Blood* that comes from the *superior Parts* of the *Body*, is diverted by the *Isthmus* of the *Cava* from the *foramen Ovale*, and falls into the right *Ventricle*, which throws it into the *Arteria Pulmonalis*, from whence by the communicating *Canal*, it is immediately carried into the *Aorta*; so that the *Blood* that comes from the *Cava ascendens*, passes only through the right *Ventricle*, whilst that which comes from the *Descendens*, passes only through the left *Ventricle*. The reason of which *Passages*, is because the *Blood* in the *Fætus* cou'd not go thro' the *Lungs*, their *Vesicles* by their compressure upon the *Blood Vessels*, obstructing that *Course*; neither indeed, did the *Blood* need to pass through the *Lungs*, the *Fætus* being nourished from the *Mother*, whose *Fluids* had already receiv'd, all the *Advantages* that it cou'd reap from the *Air*, in her *Lungs*; but when it comes into the *Air*, and is no longer nourished from the *Blood* of the *Mother*, this *pressure* is taken off from the *Blood Vessels*, by the distension of the *Lungs*, after the manner already explain'd. And so finding a free *Passage* through the *Lungs*, it runs no more by the communicating *Canal*: And so that dries up; and by the *Current* in the *Pulmonary Vein*, the *Valve* of the *foramen Ovale* is shut so, that the *Blood* can no more

pass that way from the *Cava*. Now how wisely are these different Channels for the Blood contriv'd, for the different necessities of the *Fœtus*, before and after its Birth! This is a plain Indication of *fore-knowledge*, and such an one as nothing but Omniscience, is sufficient for. And this is certainly one of the most convincing Proofs of *Design* and *Counsel*, that can possibly be wish'd for; for to provide for an Event, that in the natural Course of things, must happen a long time after, is an infallible evidence, that the thing was foreseen, and the Provision design'd, by some intelligent Being. But this is not the only Instance of a *Precaution*, for it's evident, all the several Steps of the *Growth* and *Vegetation*, both of *Animals* and *Plants*, have been foreseen, and fore-design'd, by the wise *Author* of *Nature*; seeing, different Provisions are made, and different Circumstances adjusted, for these various Periods of their Lives.

§ XLV. What a noble piece of *Geometry* is manifested in the *Fabrick* of the *Eye*, and the manner of *Vision*! Without this *Organ*, *Animals* cou'd not provide themselves with Food, nor be forewarn'd of approaching Danger, and consequently, cou'd not guard against it; without the Benefit of *Light*, the animated part of this *System*, wou'd be but so many *Puppets*, toss'd up and down by Chance and Fortune, without House or Habitation, and depriv'd

priv'd of all the Pleasures and Conveniences of Life. What a miserable State wou'd it be, to be confin'd to perpetual Darkness, and never to behold the chearful Light? The Misery of such a Life is beyond Expression and Conception: And on the other Hand, what can be more amazing, than that the Particles of Matter shou'd be so fram'd, as by their means to shew us the *Shapes, Positions, Distances, Motions*, yea and *Colours* of remote Bodies? How wonderfully must the several Coats and Humours of this little Ball be dispos'd, to transmit through them that fine, and subtile Fluid, which is emitted from *luminous* Bodies, and reflected from the Surfaces of *Opake* ones; and united on the bottom of the *Eye*. These things are not only contriv'd and fram'd with so great Wisdom and Skill, as not to admit of a better; but to any one who attentively considers them, they seem of such a Nature as scarcely to allow any other Method, for it seems impossible that *Light* shou'd represent *Objects* to us, at so vast a distance, but by the transmission of some fine Fluid, from the *Objects* upon the *Eye*. And it seems impossible that any other Composition of the *Eye*, shou'd be equally fitted for that end. The *Globe* of the *Eye* is *spherical*; it is compos'd of six *Coats*, and three *Humours*, the first *Coat* is call'd the *Conjunctiva*, and makes the White of the *Eye*. The second *Sclerotica*, it is thick, hard, and smooth, *Opake* behind,

behind, but *Transparent* before; where it makes the third Coat call'd the *Cornea*, from its Resemblance to a piece of *Transparent Horn*, it has a greater convexity, than the rest of the *Globe* of the *Eye*, consists of several *Laminae*, which are nourish'd by so small Blood Vessels, as to obstruct very little of the *Light*. It is of an exquisite Sense, that upon any touch, the *Tears* might be squeez'd from the *Lachrymal Glands*, to wash and clean it. The fourth Coat is the *Choroides*, it lies under the *Sclerotica*, it hath little *Glands* which separate a black *Liquor*, which *Tinctures* the internal side thereof (which is otherwise of a whitish Colour) for hindring the reflected *Light* from disturbing the *Pictures* of *Objects*; this Coat has a Hole before, which it called the *Pupilla*, for admitting the *Light*. The fifth is the *Uvea*, which is nothing but the *Circumference* of the *Pupilla*; It is compos'd of circular and straight *Fibres*, to contract or dilate, according to the strength or weakness of the *Light*, for when the *Light* is too strong, the *circular Fibres* contract the *Pupilla*, that their Force hurt not the *Eye*; and when it is weak, the straight *Fibres* dilate it, to let in more *Rays*, for the more distinct *Vision*. On the inside of the *Uvea* from its *Circumference* which joins the *Choroides*, rises the *Ligamentum Ciliare*, by which the forepart of the *Eye* is press'd outward, and the *Retina* backward,

or

or the *Axe* of the *Eye* lengthned, at the approach, of too near Objects. The sixth *Coat* is the *Retina*, which covers like a Net the bottom of the *Eye*, it is only a fine expansion, of the *Fibres* of the *Optick Nerve*; upon this *Coat*, the Pictures of Objects are fram'd. The first Humour is call'd the *Aqueous*, it lies immediately under the *Cornea*, it is thin and liquid, and of a spirituous Nature, infomuch that it will not freeze in the greatest Frost. The second is the *Chrystalline*, next the *Aqueous*; it is convex on both sides, and resembles a double convex *Lens*; it is covered with a fine *Coat*, call'd *Aranea*. The third is the *glassy* Humour, it is thicker than the *Aqueous*, and thinner than the *Chrystalline*, it gives a *Spherical* Figure to the *Eye*, upon its back part, is the *Retina* spread, which it keepeth at a distance from the *Chrystalline* Humour, requisite to receive the distinct impression of Objects. The *Optick Nerves* are inserted in the inside of the *Optick Axes*, whereby the middle point of every Object is distinctly seen, for the Center of the Insertion of the *Optick Nerve* is insensible, as Monsieur *Mariotte* has shewn by Experiment. And consequently, had the Center of the *Optick Nerves* coincided, with that of the *Retina*, the middle point of any Object, had been invisible; but by this lateral Insertion of these *Nerves*, the point of the Object which is invisible in the one *Eye*, becomes visible in the

the other ; for it is impossible, that the Rays shou'd fall on the inside of both *Eyes* at the same time. The light which comes from the several points of Objects, is so refracted (by the *Cornea* and *Chrystalline Humour* principally) as to meet again upon the *Retina*, and there to paint in the same Order and Proportion, with the Object, the Image thereof, (as is evident by taking off that part of the *Dura Mater*, which covers the backside of the *Retina*, from the *Eye* of any dead *Animal*, and then placing the *Eye* in a fit Hole, of a dark'ned Room ; for looking then upon the back part of the *Retina*, we shall see through it, the Pictures of external Objects painted upon its inside) and these Pictures propagated by Motion, along the *Optick Nerves*, are the Cause of *Vision*. Now what can be more admirable than this structure of the *Eye* ; ev'ry part contributing something toward its Perfection. It is situated in the *Head*, the most eminent part of the Body, next to the most noble and vital *Organ*, in the whole Composition : Either in the fore part, or the sides, according to the necessary occasions of the Animal: In *Man* it takes in but a *Hemisphere* of *Vision*, in *Birds* almost a whole *Sphere*, and in some timorous Animals, as *Hares* and *Conies*, their *Eyes* being so protuberant, and placed so far backwards on the sides of their *Heads*, they must see a whole *Sphere* quite round, with the least Motion of these *Organs*.

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The *Cornea* is more *convex* than any other part of the *Eye*, by which all the Rays are gathered, to pass through the *Pupilla*, and few of 'em lost on the *Uvea*. The *Aqueous Humour* being thin, easily changes its Figure, either when the *Ligamentum Ciliare* contracts, or both the oblique *Muscles* protrude, the Bulb of the *Eye*, to render it oblong, when Objects are too near; the *Fibres* of the *Uvea* contract or dilate the *Pupilla*, according to the Degrees of the Strength of the Light. The *glassy Humour* keeps the *Retina* at a due distance from the *Chrystallin*, the Images are painted upon a Skin, produc'd by the Expansion of the *Optick Nerves*, for the more easy conveyance of the Impression to the Brain. The *Choroides* is tinctur'd black, that the Rays that pass through it may not be reflected back again upon the *Retina*, and so confound the Object. The *Optick Nerves* are inserted on the inside of the *Axes* of the *Eye*, that the whole Object may be distinctly view'd; the Hairs of the *Eyebrows*, with those on the *Eyelids* defend it from filth and light Bodies that swim in the *Air*; the continual Motion of *Eyelids*, moisten and sweep the *Cornea*, else it would dry or grow dirty; it is sunk in a Hole, wall'd with a strong Bone, to keep it from more powerful Injuries. The several refractive Virtues of the *Coats* and *Humours*, serve to correct the Errors arising from the different *Refrangibilities* of the Rays of Light.

Light. Our Eyes are double, to secure both sides from Danger, because if the Objects were near, however one *Eye* were plac'd, we cou'd not distinctly perceive them that shou'd be situated towards the sides of our Body, and so cou'd not guard our selves from the Dangers, thence arising. Besides, we cou'd not distinguish the distance of Objects by one *Eye*, for our two *Eyes* are like two different Stations in *Longimetry*, by the assistance of which, the distance between two Objects is measured. As also, when one *Eye* is accidentally rendred useless, we enjoy the Blessings of this so necessary a Sense, by the Benefit of the other. It is observable that the Figure of the *Chrystallin* Humour of Fishes, is a great deal nearer to a *Sphere*, than that of Land *Animals*, and that because of the different refractive Virtue of Water from Air, for that convexity which wou'd unite the Rays of Light coming through Air, will not unite the same so perfectly at a point, in the same distance, coming through Water. In those *Animals* that gather their Food from the Ground the *Pupill* is *Oval* or *Elliptical*, the greatest *Diameter* going transversely from side to side; in those that seek their Food on higher Places, its greatest *Diameter* goes from the top of the Head towards the Feet *perpendicularly*; these two different Figures being wonderfully fitted to the different necessities of these *Animals*. Those living  
Creatures

Creatures that by their Figure, and for other reasons, have no Motions of their Neck, have a Cluster of *Hemispherical Eyeballs* which send in the Pictures of Objects all around them; and those that seek their Food in the dark, have their *Retina* coloured white, which reflects the light and enables them to see best in the least light; these are wonderful and surprizing Instances, of *Foresight* and *Counsel* in that Being that fram'd these *Organs*; but that which to me is most surprizing in this Affair, is that in all Animals, whose *Organs* are sound; they shou'd have been so nicely fram'd in all the infinite possible Varieties over and under, as to represent Object at a due Distance, of that Magnitude that has the justest Proportion and truest Analogy, to the Magnitude of each particular Animal. What the real Magnitudes of Bodies are, I doubt no body can justly tell, nor were it of any use to us to know, since their *Analogical* Magnitudes to the Magnitude of our Bodies, is all that we have any Concern about. Thus taking our own Hand, Foot, or Height for our Standard, all things about us are represented in a constant uniform Proportion to these, so that we are thereby informed of that Distance and Magnitude of Objects that is most natural and familiar to us, and is also most necessary for our Security and Preservation: And the same is true of every other Animal small, or great, thus take an *Elephant*, a *Man*, and a *Mite*,

*Mite*, and present the same Object to them all three, and it shall appear, not of the same Magnitude to them, but in a Magnitude in some sort, reciprocally proportional to their own Bulks, that is, to the Elephant, less than to the Man, and to the Mite, much greater than to either, and this of necessity from the different Magnitudes, and Fabrick of their *Nerves* and *visual Organs*; and for the necessity of their Preservation, and seeking their Food. Now we know from the *Laws of Opticks*, that had the *Retina* been remov'd farther from, or brought nearer the *Chrystallin Humour*, or (keeping the *Retina* at the same Distance from that Humour) had it consisted of two *Segments* of a less or greater *Sphere*, the Vision had been indistinct or none at all; or had the Distance been fitted exactly in the *Focus* of the *Chrystallin*, but had it consisted of *Segments* of *Spheres*, less or greater, than those of our *Chrystallin Humour*, that are at present, we had seen Objects ev'n at a due Distance, either bigger or less than we now behold them, which wou'd have expos'd us to a thousand dangerous Mistakes; for Example, the Precipice that perhaps was not many Feet from us, might have appear'd at some Paces Distance, and we have tumbled down, ere we were aware, or the *Atom* that we now scarce take Notice of, wou'd have covered all our view, and hindred us from taking in any other Object; in a Word, besides that  
thus

thus we shou'd not have discovered that *Magnitude* of Objects, which has the most proper and fit Analogy to us, which wou'd have had a Thousand fatal Consequences, had our Eyes magnified Objects, any thing considerably, we cou'd have seen but a very small part of them at once, and Twenty dangerous things might have been in our ways, which we cou'd not have discovered, but by a great deal of Pains; so that our progressive Motions, must have been slower than those of *Reptils*, and then ev'ry little Particle, likewise, wou'd have been able to have damn'd up, and obstructed our Sight; and had our *Eyes* diminished Objects considerably, we cou'd have seen them but faintly and indistinctly, all minute Bodies wou'd have vanished, and we might have been destroy'd by those which we thought at a distance. In one Word, there are infinities of different Ways, our *Eyes* might have possibly been form'd, none of which cou'd have brought with it, the Advantages the present Structure does. Can there then be a more pregnant and convincing Evidence of the *Being* of an *infinitely wise* Power, who out of the infinite possible Varieties, of disadvantageous Fabricks of this *Organ*, has singled out that only one, that was best; he certainly deserves not to enjoy the Blessings of his *Eye Sight*, whose Mind is so deprav'd, as not to acknowledge the Bounty and Wisdom of the Author of his Nature, in the *ravishing* and *astonishing* Structure of this noble *Organ*.

§ XLVI. *Hearing* is the next Sense in Dignity to *Seeing*, (for I reckon *Feeling* a general one, of which the rest are only particular *Modifications*) without which our Lives wou'd be very Comfortless. It is by Means of this Sense, we enjoy the Benefits of Conversation, and the Pleasures of *Musick*; and by it we are forewarn'd of those Dangers, our Eyes cannot inform us of; and what can be more wonderful than that the same *Medium* of Air, shou'd serve us for so many different, yet necessary Uses: By it our Vapours are supported, and buoy'd up to the higher Regions, to be there form'd into Snow or Rain, according to the Exigencies of different *Climates*; by it's Motion our Winds are produc'd, which sail our Ships, and purify our *Atmosphere*; by drawing it in we live, and our Blood is fitted to perform its *Circulations*; by it Sounds are convey'd to our *Ears*, and other Mens Thoughts to our Minds. The internal Parts of the *Ear* are these, 1. The *Meatus Auditorius*, which is a contorted Passage for the outward Air, running first upward, and then downward; here are many *Glands*, which separate a viscid glutinous Matter, which hinders Insects, or any hurtful thing, from corroding the *Tympanum*, which is a second principal part of the internal *Ear*. It is a thin *Membrane*, like the Head of a Drum, stretch'd upon a Bony Circle, behind which is the *Barrel*, in the Cavity of which there are four little Bones call'd the *Hammer*,

the

the *Anvil*, the *Stirrup*, and the *Os orbiculare*. In this *Barrel* there are several Holes, one of which opens, behind the *Palate* of the *Mouth*, and receives *Air* to supply these *Cavities*, that have no *Communication* with the *Air*, coming in by the outward *Ear*. Next to the *Barrel*, is the *Labyrinth*, which ends in the *Vestibulum*, and is follow'd by the *Cochlea*, which is a *Passage* resembling a *Snail's Shell*, in it the *Auditory Nerves* terminate. Now when a *Sound* is propagated in *Undulations* through the *Air* (the *Sonorous Body* striking the *Ambient Air*, by many repeated *Vibrations*, excites these *undulations* in it, after the manner any heavy *Body* thrown into a standing *Lake*, raises in the *Water*, *Waves* in a *Circle* round it) these are gathered by the *Concha*, or external *Ear*, and carried through the *Meatus Auditorius*, to the *Tympanum* or *Drum*, on which beating, the four little *Bones* that are in the *Barrel*, are thereby mov'd; and as the *Drum* is struck by the external *Air*, after the same manner is the internal *Air* mov'd by these little *Bones*; and this internal *Air*, thus mov'd, makes an *Impression* upon the *Auditory Nerves*, in the *Labyrinth* and *Cochlea*; so that as the external *Air* strikes the *Drum*, so does it move the *Bones* in the *Barrel*, to strike the internal *Air* after the same manner; and as it is mov'd, so accordingly is the *Impression* made upon the *Auditory Nerves*, and all this *Apparatus* seems intended, to hinder the *Sound* from coming with too

great Violence upon these *Nerves*, for we find that too sudden, and violent a Noise, is still able to disturb these slender *Tubes*, and sometimes to disorder them so, as to deprive us of this *Sense*. Now how wisely is this necessary and pleasant *Sense* contriv'd, for the Conveniences of Life! Had it been more exquisite, than every little Noise had been capable of disturbing us, the buzzing of a Fly, or the Noise of our own Breath, wou'd have pierc'd our *Ears* like a Peal of Thunder; and the Motion of every little *Atom* wou'd have rob'd us of Rest; and had this *Sense* been any thing considerably more dull, we shou'd have been in proportion thereto, depriv'd of all the Pleasures and Advantages thence arising: So that it's evident our *Hearing*, is nicely adjusted to the Conveniences and Necessities of Life, which is a plain Instance of *Design* in the Fabrick of this *Organ*; the same might be demonstrated of the two remaining Senses, which for Brevities sake I must now omit.

§ XLVII. I have before observ'd, that all the Canals except the *Arteries* have *Valves*, by which their Fluids are permitted to go forward, in their Course, but hindered from returning back, all these *Valves*, opening toward the term of the natural Motion, of these Fluids, but shutting by the Pressure of the Blood in a contrary Direction, and thereby obstructing that backward Motion. These *Valves* are visible, not only in the *Veins* but in the *Lymphaticks*,  
the

the *Lacteals* and *Ductus Thoracicus*; and it is observable that this last *Channel* always goes up the left side, that by the Pulsation of the great *Artery*, upon which it immediately lyes, the *Chyle* may be propell'd upward. It is likewise remarkable, that all the Branches of the *Arteries* which go off, at any small Distance from the *Trunks*, do all unite again in one *Trunk*, whose Branches communicate with one another, and with others, as before; and that for this wise End, that when any small *Artery* is obstructed, or cut, the Blood may be brought by the communicating Branches, to the Parts below the Obstruction, which must have otherwise been depriv'd of Nourishment. The *Velocity* of the *Blood* in the extreme *Arteries* is considerably less, than that of the same at the *Heart*, or its entry into the *Aorta*, because it is of these extreme *Arteries* the *Glands* are form'd, and by them the secretions are made, which as was before demonstrated, require different *Velocities* in the Blood, to discern the different *Fluids* in these *Glands*: This Diminution of the *Velocity* is evident from the Proportions Dr. *James Keill*, (to whose *Accurate Compendium*, of the *Anatomy of Humane Bodies*, I have always had recourse, where my Memory fail'd me) has giv'n us all the Branches of the *Arteries* to the great *Trunk*, whereby it appears the *Diameter* of the *Aorta*, does not bear a greater Proportion, to the primary Branches of the *Arteries*, than 5 to 7: And doubtless the odds is greater in the smaller Branches.

Branches. How frugal has Nature been in the Structure of the *Veins*! for because of the less Pressure of the *Blood*, against the sides of these widening Channels, the thickness of their Walls is in proportion less, than those of the *Arteries*. Besides, that only those *Veins* that run *perpendicular* to the *Horizon*, are endow'd with *Valves*, which stick to their Sides like so many Thimbles; which when the Blood presses back, are fill'd, and so stop its Passage, but are compress'd by the forward Motion of the Blood. Now these *Valves* were useless in other *Veins*, for their widening Channels, give no occasion to the Blood to push backward, its Gravity acting laterally and not backward, as in those *perpendicular* to the *Horizon*; the small Branches of these *Veins*, communicate with one another, for the same ends and purposes that the *Arteries* did; and having now occasion to speak of the containing Vessels, I cannot omit here the wonderful Contrivance of Nature in the Position of the several Parts of the *Fetus* in the *Uterus*; the *Skull* whereof in the first part of the time of its *Gestation* being very thin, large and only *Membranous*, the *Thorax* and *Abdomen* with the *Limbs* are so dispos'd as to make the Head always emerge out of the Fluid it lies in, or at least preserves it in a Direction that it is still upward, with its Face toward its Mother's Belly, but about the time of its Delivery the *Skull* thickens, and hardens, the *Limbs* and Members stretch out, and so the Head becomes the heaviest place in the Body whereby it tumbles over, and acquires that Posture which is fittest for its Delivery. These are signal Instances of Counsel and Foresight, in the Formation of these *Organs* and Parts, but I hasten to a Close.

§ XLVIII. Having I think sufficiently made out that great Truth, to wit, that we are wonderfully

fully made, though I have pointed only at a few of those Instances that the *Animal* Fabrick and *Oeconomy* affords, I now come to make a few general Observations under one Head, and so to put a Close to this *Chapter*. It is very remarkable, that those *Animals*, *Plants*, and *Minerals*, that are of most use, and advantage to us, are such as will grow almost in every *Soil* and *Climate*, and are more productive of their kind than others, and are found in most Places. Thus *Iron* is found almost every where, *Corn* is the Product of all *Soils*, and *Climates*, while other more curious and nice *Plants* will only thrive in their proper *Soils*: Thus *Hens*, *Geese*, and *Turkies* are more Productive than *Crows* or *Jackdaws*, and *Cornies*, and *Hares*, than *Foxes* or *Lions*; thus a *Crane*, which is but scurvy Meat, lays but two Eggs, and the *Alca* and some other *Sea Fowls*, but one, whereas the *Partridge* and the *Pheasant* hath Fifteen or Twenty, and those which lay fewer, and are of most value for Food, lay oftner, as the *Woodcock* and the *Dove*. What is more admirable, than the fitness of ev'ry Creature for the use we make of him? The docility of the *Elephant*, so long employed in War, the Insufficiency of the *Camel*, for travelling in the parch'd and dry Deserts, the gentleness of the *Sheep*, the Cleanness, Beauty, Strength, and Swiftnes of the *Horse*, whose Breath, Foam, and ev'n Excrements are sweet, and thereby so well fitted for our Use and Service! How frugally has Nature avoided any useles Expence of *Organs*, when the Circumstances of the *Animal* wou'd have rendred 'em so? Thus those *Animals* that are slow of their Nature, have no very quick sight, it being useles to such, since their slowness allows them time to dwell longer on an Object, as *Snails* and  
*Moles*;

*Moles*; but these that are endow'd with a quicker Motion, have brisker Eyes, and a more quick piercing Sight, as *Hawks* and *Hares*. Those *Animals* also, that have no Ears have no *Organs* for making a noise with; because wanting Ears, these other wou'd be useless, as *Fishes* and other Inhabitants of the watery *Element*. So also, those *Animals* which have Teeth on both Jaws, have but one Stomach, because these Teeth render more Stomachs useless; and those *Animals* that have no upper Teeth or none at all, have three Stomachs to supply the want of these Teeth; as in Beasts, the *Panck*, the *Reed* and the *Feck*; and in all granivorous Birds, the *Crop*, the *Echimus* and the *Gizzard*. A Man which has a bigger Brain in proportion to his Body than any other *Animal*, has a better and more easily manageable Hand; whereas a *Monkey* that has little Brains, and consequently can have no great use for much dexterity, has not so well a shap'd nor easily applicable a Hand. These, and a Thousand such Instances of *Wisdom*, *Counsel*, and *Meliority* in the Contrivance and Fabrick of the several *Animals*, may be gathered by any one who will consult the Writings of natural Historians. But those who will not be convinc'd by the Instances I have brought, that there is a God who rules in the Kingdoms of the Earth, who number'd all our Parts, and appointed them out their several Ends and Uses, I am afraid will not be prevail'd upon by those behind.

The End of the First Part.

PHILOSOPHICAL  
PRINCIPLES  
O F  
RELIGION.

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PART II.

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Containing the *Nature* and *Kinds*  
of *Infinities*, their *Arithmetick* and  
*Uses*, and the *Philosophick Prin-*  
*ciples* of *Reveal'd Religion*, now  
*first* published.

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By GEORGE CHEYNE, M. D. and F. R. S.

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L O N D O N :

Printed for *George Strahan* at the *Golden*  
*Ball* in *Cornhill*, over against the *Royal*  
*Exchange*. MDCCXV.

The PREFACE

To the Second PART.

BEFORE the Reader takes the trouble to enter on the Second Part, it's fit he be apprized of a few things, that may prevent his mistaking my meaning, in the more difficult Propositions, or may enable him to run thro' the whole with more Pleasure.

I The first Chapter is intended only, as an Introduction to the Two subsequent, to the Third especially, and for clearing up and demonstrating in the most familiar and easy way, the Nature and Properties of Relative Infinites. The Foundations of the Arithmetick of Infinites, and the Structure built thereon, published by me in the former Edition of this Work, having been doubted of, or mistaken by some. The whole now, I hope, is clear and unquestionable. I have borrowed a few things from the Third Chapter, for the sake of those, who either might not have Humour and Leisure, or might not have apply'd themselves sufficiently to such Studies, as to be able to goe quite through that Chapter. And yet might be content to see this curious Speculation established here.

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# The P R E F A C E

## To the Second PART.

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## The P R E F A C E.

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II. The *Second Chapter* contains many Particulars of Weight and Moment. The *Foundation* is this. The *Supreme Creator* of all Things, and the whole *System* of Creatures, from the highest *Seraphim* down to *Brute Matter*, are here together considered as it were an *Infinite Cone*, (like the *Shadow* of the dark side of the *Earth*, circumscribed by the *Light* of the *Sun* in the empty Spaces of our *System*;) whose *Base*, is the *Supreme and Absolute Infinite*, the Origin of the Being and Faculties of all created Things; and its *Body*, is the whole *System* of Creatures, from the highest *Spiritual Intelligence*; descending in a perpetual Subordination, and continual Scale, down to *Brute Matter*; or if there be any Creature lower than this. It is true, in this *Metaphor* or *Resemblance*, the *Base* is to be supposed at an *Absolutely Infinite* Distance, from the *Body* of the *Cone*. (as the *Sun*, whose *Rays* define the dark *Cone* of the *Earth's* *Shadow*, is distant from the *Earth*) But then, as all the *Sections* in a *Cone*, Parallel to the *Base*, are similar to the *Base* and to each other. So in this *perpetual Scale* of Creatures, considered in one view, together with their *Creator*, every *Species* and set of Creatures is similar to the *Base*, and to every other *Species* and set of Creatures, from the Highest to the Lowest, *i. e.* every *Species* and set of Creatures of a higher Order, has the great *Lineaments*, and prominent *Out Lines* of their *Base*, the Origin of all Being and

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## The P R E F A C E.

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Perfections, more strongly, clearly, and largely represented and express'd on and by them, and every *Species* and *set* of Creatures of a lower Order, has the same *Lineaments* and Characters, represented and express'd on and by them, but in a more Weak, more Faint, and more contracted manner. And since *Life*, *Activity*, and *Fecundity*, are among the most *Universal*, *Primitive*, and *Original* Qualities, of the *Base*, the *Source*, and *Origine* of all Being and Perfections: So every *Species* of Creatures and each individual of every *Species*, must in a higher or lower Degree, according to their Rank in the Scale of Existence, partake of those *Primitive* and *Original* Qualities. If this *Principle*, and *Foundation*, thus shadow'd out, may be allow'd me, and sure methinks it is Evident, from the Nature of Things *à Priori*, from all Experiments and Observations hitherto made on our *Material System* of Things, *à Posteriori*, and even from the most genuine and simple reflections of our Minds within our selves. Then it will follow,

I. That there is a perpetual *Analogy*, (Physical not Mathematical) running on in a Chain, thro' the whole *System* of *Creatures*, up to their *Creator*.

II. That the Visible are Images of the Invisible, the Sensible of the Insensible, the *Ectypical* of the *Archtypical*, the *Creatures* of the *Creator*, at an absolutely infinite distance.

III. That the Arguments from the *Attributes* of the *Creator*, to the Qualities of the *Creature*,

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with due regard to the absolutely *infinite* distance, is Just and Conclusive, & *vice versa*.

IV. That, as there are *Objects*, intirely opposite and *disparata*, so there must be *Faculties*, in Intelligent Creatures, suited to those different *Objects*, differing, according to the diversity of the *Objects*.

V. That if *Gravitation* be the Principle of *Activity* in *Bodies*; That of *Re-union*, with their Origin, must by this *Analogical* Necessity, be the Principle of Action in *Spirits*.

VI. That *Material Substances*, are the same with *Spiritual Substances*, of the higher Orders, at an infinite distance, or that *Material Substances* are *Spiritual Substances* infinitely condensed or contracted, since in the *Scale of Existence*, the *first* are supposed at an *infinite* distance from the *latter*.

VII. That, there is some *Analogy* between the *Constitution*, Temperaments and Complexions of *Spiritual Beings*, and the known different Textures, *Elements*, and *Faculties* of *Material Substances*.

These I think, as they are necessary Consequences from the preceeding Principle, so they are the main Pillars, and some of the principal Propositions of this *Second Chapter*, which, if understood and granted, every thing else will either be easily receiv'd, or may be safely rejected, without any hazard to the main *System*.

After all, seeing my whole Intention and Design, in advancing and publishing these *Specula-*

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## The P R E F A C E.

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*culations*, was to beget in the Minds of Men, Noble, Generous, and Magnificent Sentiments, of God and his Works, that, thereby they might be more powerfully engaged, to Love, Adore, and Serve Him. To convince them of the *Degeneracy* and *Corruption* of the whole Race of Mankind; of the necessity, of expanding and cultivating their *Superior* Faculties, by a faithful Obedience, to the Divine *Attraction* and *Drawings* in their Hearts; and thereby, of begetting in their Souls, *Charity*, or the *pure Love* of God, and of all his Images in a proper Subordination: All which can by no other Means be brought about, but by a careful copying after, and imitating the *Model* and *Pattern* the BLESSED JESUS has set us in his Life and Doctrine. I say since this was my whole end and aim, in advancing and publishing these *Speculations*. If any Person, shall think fit to contravert them, he may do it very safely for me. For being satisfied, in the Honesty and Simplicity of my Intentions, and of the Use and Benefit these *Speculations* have been to my self, for these Ends and Purposes. I am firmly resolved, not to spend my time in idle Disputes. If others differ with me, about the Truth and Reality of these *Speculations*, or their usefulness to, and influence on the Ends proposed, or are not dispos'd to relish or receive them, they may let them alone or reject them, it is equal to me. All I shall be ever prevail'd on to do, in such a case (ex-

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cepting always, in case those who either are my *lawful Superiors*, or whom I look on my self obliged in Conscience to obey, shall command otherwise,) shall be; to amend, alter, or retract, what I shall be perswaded is amiss in the future *Editions* of this Work; if it shall have any more.

III. The *Third Chapter* is what the *Reverend and Ingenious Mr. John Craig* sent me about Seven Years ago, when I desired him (being low in my Health, and otherwise engaged) to write me down his Thoughts on, correct or alter, what I had formerly published on this Head in the *first Edition* of this Work, in order to a Second Edition. I have altered or added nothing, but one *Note* before his *Additions*, and that in *Italick Characters*.

To conclude, if any Person, by either of the Parts of this Work, shall be moved to Adore, Worship, or Love, the *lovely and adorable Author of his Being*, (who is wonderful in all his Works, and great in the least,) I say, if any one shall be wrought on thereby, to love Him more, or serve Him better, I shall have the whole reward of my Labour, having intended it solely for his *Glory* and the *Good* of my fellow Creatures; and having I hope, in the whole, and each single part, as far as my Weakness and Corruption wou'd permit, disengaged my self, from all *sinister Ends*, from all *Fraud*, *Malice*, *Vain-glory*. and *Hypocrisy*.

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### *Advertisement.*

THE Errors of the Prefs, in the *first Part*, not being such as can stop the *Intelligent Reader*, I beg he will mend the following ones, of the first and second Chapters of the *Second Part*, which were the most Material I could observe. *Page 8. Def. 9.* *Relative Nothing* is said here to be generated by a perpetual *Substraction*, tho' the Signs be alternately + and -. for these Reasons, because *Relative Infinite*, was said to be generated by a perpetual *Addition*, and because that after the first Term, every Two succeeding ones in *Relative Nothing* is equivalent to — 0 1 thus

$$1 - 1 + 1 - 1 + 1 - 1 \&c. \text{ is } 1 - 1 + 1 - 1 + 1 - 1 + 1 - 1 + 1 \&c. = 1 - 0 1 - 0 1 - 0 1 \&c. \text{ and so}$$

in

in other Cases. *p.* 22. *line* 10. for effect read  
affect : *p.* 27. *l.* 10. for  $\infty^{n-1} : n :: 1 : 0$ . read  
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*l.* 21. instead of Limit, *r.* Light. The Er-  
rors of the *Third Chapter*, will not stop  
those who wou'd otherwise understand it.

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Part II.

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## PART II.

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### CHAP. I.

*Of the Nature and Kinds of Infinites. Of some of their respective Qualities, and of a New Arithmetick of Infinites.*



**H**AT we may reason as cautiously as possibly we can, about Matters so intricate, and so far remov'd from the common way of Thinking, as the Nature and Qualities of *Infinites*, and the other Subjects of this Chapter are; we shall begin with *Definitions* and *Axioms*, and proceed to some *General Propositions*, demonstrated after the plainest manner, till we

B

obtain

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## 2 Philosophical Principles

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obtain *Principles* to found our consequent Reasonings on; and then draw such Corollaries, from the several Parts, or from the whole, as arising necessarily from them, may be of use, to ascertain some Speculations advanced in the foregoing *Treatise*; or may otherwise help, to conduct the Understanding in those other *Sciences*, where they may find a place.

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### *Definition I.*

QUANTITY is what may be encreas'd or diminished.

Tho' this *Definition* may not exhaust the *Metaphysical* Nature of *Quantity*; yet it points out that *Quality* in it, that is here chiefly regarded; for ev'ry quantity may be encreas'd or diminished, and that continually, as shall be afterwards shown.

### *Definition II.*

A BODY is an extended, impenetrable, passive, divisible, unintelligent Substance.

This *Definition* also, tho' it exhaust not, the internal essence and intimate Nature of Matter, yet it sums up, its sensible and most constant *Qualities*, by which it is distinguished from every thing else.

*Defi-*

## Definition III.

The inherent *Principle* of *Activity*, in the great Bodies of the Universe, is *Gravitation* or something *analogous* thereto.

Tho' I am perfectly convinced, from the Simplicity and Uniformity of the Divine Nature, and of all his Works, that there is some one great and universal *Principle*, running through the whole *System* of Creatures *analogically*, and congruous to their Relative Natures; which is the same in all Bodies great and small, and the *Origin* of all their Natural Actions upon one another, with regard to their different Circumstances; and that there is not a different *Principle* for the Natural Actions of the *Lesser Bodies* from that which is the *Principle*, of the Natural Actions of the *Greater Bodies* of the Universe, but one and the same *Principle* in both, acting differently in different Circumstances. Yet since *Gravitation*, or some thing *Analogous* thereto, seems necessary for accounting for the Constant and Regular Motions, and Actions upon one another, of the *Great Bodies* of the Universe. *Gravitation* or something *Analogous* thereto must be a necessary Consequence in the *Greater Bodies* of the Universe, of this more Universal Principle, and the *Origin* of the Activity of *Bodies*.

*Definition IV.*

A SPIRIT, is an extended, penetrable, active, indivisible, intelligent Substance.

*Body* and *Spirit* are in ev'ry other Quality opposit, except in *Extension*, therefore as the foregoing *Definition* of *Body*, summs up its sensible and most constant qualities, so to assign the *Definition* of *Spirit*, there was nothing to be done, but to joyn the opposite Qualities of *Body*, to that of *Extension* or extended Substance.

*Definition V.*

The *Principle* of Action in Spiritual Subsistences, is, or ought to be, that Essential one of REUNION with the *Origin* of their Being, impress'd on ev'ry Individual of this Rank of Creatures.

The Universal *Principle* of *Action*, mentioned in the third *Definition*, that runs through all the *System* of Creatures, must *analogically* be carried through ev'ry Individual of *Spiritual* Beings, and can be nothing but this Essential Principle of REUNION with the *Origin* of their Being, as shall be afterwards demonstrated at large.

*Defi-*

## Definition VI.

A *finite Quantity* is that, of which the Bounds or Limits, beyond which it cannot reach, is *assignable*.

Thus a *Line* is finite, when both its Extremities are given, or the Points which are its Limits, beyond which it cannot reach, are *assignable*: An *Area* is finite, when its terminating Lines are *assignable*; a *Solid* is finite, when its terminating Planes are *assignable*, a *Number* is finite, when the Unities (which are its Limits) of which it consists, or the bounds beyond which it cannot reach, are *assignable*.

## Definition VII.

An *Infinite Quantity* (in its simplest nature and lowest degree) is that, some one or more of the Limits or Bounds of which, beyond which it cannot reach, are not *assignable*.

Thus a *right Line*, one or both of whose Extremities are not *assignable*, or the Points beyond which it cannot reach, are not *assignable*, is an *infinite right Line*. An *Area*, one or more of whose terminating Lines are not *assignable*, is an *Infinite Area*; a *Solid*, one or more of whose terminating Planes,

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## 6 Philosophical Principles

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are not *assignable*, is an *Infinite Solid*. A number, encreasing continually, whose last encrease, is not assignable, or the Bounds beyond which it cannot reach, is not *assignable*, will at last make an *Infinite Number*.

### *Scholium.*

An *Infinite Number*, may be suppos'd to be Generated, by the perpetual Addition of a finite Number to it self. Thus  $1 + 1 + 1 + 1 + 1$ , &c.  $a + a + a + a + a$  &c. become infinite. Or, it may be supposed to be Generated, by the perpetual Addition of finite Numbers, encreasing in a regular Progression, and in one constant Proportion one to another. Thus  $1 + 2 + 4 + 8 + 16$ , &c. (where the finite terms, perpetually encrease in the *ratio* of 1 to 2.) and  $1 + a + a^2 + a^3 + a^4$  &c. (where the finite Terms, perpetually encrease in the *ratio* of 1 to  $a$ ) become infinite. And it is the same in all other infinite *Series*, regularly Generated; or lastly, the infinite Number, may be supposed to be generated by the perpetual addition of finite Numbers, in no certain proportion one to another, nor in any regular progression, such as  $7 + 1 + 30 + 5 + 2 + 25$  &c. Of these last kinds of Infinites, we have here no consideration, for being of no constant or regular Nature, but merely casual and fortuitous, they

they can afford no *Medium* for reasoning. The Principal Design of this Chapter, so far as it concerns these two kinds of Infinites, is to find out a *Method*, for resolving the second kind of Infinites into the first when it is possible; in order then to obtain a just Notion of these Infinites, let us first distinguish Infinite in general, into *Relative* or *Creaturely* Infinite, and *Supreme* or ABSOLUTE Infinite (of which the first is but a Created Image or Picture, as will be afterwards shown) let  $\circ$  stand for finite in general, and  $\infty$  stand for infinite in general as they respect Numbers; then  $\circ$  1 and  $\infty$  1 will be finite and infinite (as they respect Numbers) of the lowest Degree and simplest Nature. Unity being the simplest number.

*Definition VIII.*

*Relative Infinite* (in its simplest Nature and lowest Degree) is an infinite Quantity, as it stands related to a given Finite, by the perpetual Addition of which to it self it is generated.

Thus  $\infty$  1. is a *relative Infinite*, as it stands related to 1, a given finite, by the perpetual Addition of which to it self, it is generated; that is,  $\infty$  1 = 1 + 1 + 1 + 1 + 1 &c. And  $\infty$  a, is a *relative Infinite*,

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as it stands related to the given finite  $a$ , by the perpetual Addition of which to it self it is generated, or  $\infty a = a + a + a + a + a \text{ \&c.}$

### Scholium.

In the same Relation, that relative Infinite stands above a given finite in *ascending*, in the same may another quantity be supposed to stand below it, in *descending*, in which Case, we shall have a *relative infinitely great* Quantity, in *ascending* above the given finite; and a *relative infinitely little* quantity, in *descending* below it. So that relative infinite in general, may be aptly distinguished, in respect of the given finite, into *relative infinitely great*, and *relative infinitely little*. For brevities sake, we shall call the first *relative Infinite*, the second *relative Nothing*.

### Definition IX.

*Relative Nothing* (in its simplest Nature and lowest Degree) is an *infinitely little* quantity, as it stands related to a given finite, by the perpetual Subtraction of which from it self, it is generated. Let  $a$  stand for relative Nothing.

Thus  $01$ , is a *relative infinitely little* quantity, as it stands related to Unity, by the per-

perpetual Subtraction of which from it self, it is generated; that is  $o 1 = 1 - 1 + 1 - 1 + 1 - 1 + 1 - 1 \&c.$  and  $o a$ , is an infinitely little quantity, as it stands related to the given finite  $a$ , by the perpetual Subtraction of which from it self, it is generated; that is  $o a = a - a + a - a + a - a \&c.$

### Definition X.

An *Indefinite Quantity* (in its simplest Nature and lowest Degree) is some mean proportional, between finite, and relative infinite or Relative Nothing.

For, as in *Descending* from 1 to 0, we do not immediately slip from finite to relative Nothing, but must necessarily pass through the intermediate steps  $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5} \&c.$  in Arithmetical Progressions; and in *ascending* from 1 to  $\infty$  we must pass through the steps between both 2, 3, 4, 5,  $\&c.$  in the same kind of Progressions. So in the *Geometrical* Progressions, in *descending* from 1 to 0, we must pass through these mean Proportionals  ${}^2\sqrt{0}$   ${}^3\sqrt{0}$   ${}^4\sqrt{0} \&c.$  and in the same Progressions, in *ascending* from 1 to  $\infty$ , we must pass through the mean Proportionals  ${}^2\sqrt{\infty}$   ${}^3\sqrt{\infty}$   ${}^4\sqrt{\infty}, \&c.$  and these we call *Indefinites*. Thus in *Geometry*, if we cou'd imagine a *Circle*, drawn upon the sum of a finite right Line representing 1, and an infinite right Line representing

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senting  $\infty 1$ , as a *Diameter*. A Perpendicular erected on the Point where these Two Lines meet, reaching the *Circumference*, wou'd represent the *Indefinite* right Line implied by  $\sqrt{\infty 1}$ . Let  $\infty$  stand for such *Indefinite* Quantities in general.

### Scholium.

Unity being the simplest *Finite* Number, by consequence  $\infty 1 = 1 + 1 + 1 + 1 + 1 \&c.$  must be the simplest *Infinitely great* Number. And  $0 1 = 1 - 1 + 1 - 1 + 1 - 1 \&c.$  must be the simplest *infinitely small* Number. And by reason the greater the Number, denominating the Root is, the less the Root it self will be, therefore  $\infty \sqrt{\infty 1}$  (= to any *Finite* Number greater than Unity) will be the simplest *Indefinite*. Put  $\infty \sqrt{\infty 1} = y = \infty^{\frac{1}{\infty}}$  therefore  $\frac{1}{\infty} L \infty = Ly$ . but  $L \infty = \infty$  (as will be seen by the last Chapter) therefore  $\frac{1}{\infty} \times \infty = Ly$ . that is  $\frac{\infty}{\infty} = 1 = Ly$ . But 1 may be the *Logarithm* of any finite Number, greater than Unity, in the Scale of proportionals  $1^0. a^1. a^2. a^3. a^4. \&c.$  therefore  $\infty \sqrt{\infty 1}$ , may be any finite Number greater than Unity. The *Indefinites* of the first degree, that is wherein the Number denominating, the Root is an integer, may be universally thus express'd

$${}^m\sqrt{a} = \frac{1}{m} \sqrt[m]{\infty} = \frac{1}{1 - 1} \sqrt[m]{1} = 1 + \frac{1}{m} + \frac{1 \times m + 1}{m \times 2 \cdot m} +$$

$$+ \frac{1 \times m + 1 \times 2m + 1}{m \times 2m \times 3m} + \frac{1 \times m + 1 \times 2m + 1 \times 3m}{m \times 2m \times 3m \times 4m} + \text{&c.}$$
 Now as  $\infty 1 = 1 + 1 + 1 + 1 + 1 + 1 \text{ &c.}$  and  $0 1 = 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.}$  and  $\infty \sqrt{\infty} 1$ . are of the simplest Nature, so also are they of the lowest Degree. The superior Degrees being generated of  $\infty 1$ , after the same manner that  $\infty 1$  is of 1, for if we add  $\infty 1$ , perpetually to it self, we shall have a *relative infinitely great* quantity, of the simplest Nature in it's kind, but of a higher Degree. *viz.*  $\infty 1 + \infty 1 + \infty 1 + \infty 1 \text{ &c.} = 1 + 1 + 1 + 1 + 1 + 1 + 1 \text{ &c.} + 1 + 1 + 1 + 1 + 1 + 1 \text{ &c.} + 1 + 1 + 1 + 1 + 1 \text{ &c.} \text{ &c.} =$  (Since a perpetual Addition of any quantity to it self, is equal to a Multiplication by  $\infty 1$ )  $\infty 1 \times 1 + 1 + 1 + 1 + 1 + 1 \text{ &c.} = \infty 1 \times \infty 1 = \infty^2$ . So  $\infty a + \infty a + \infty a + \infty a \text{ &c.} = \infty \times a + a + a + a + a + a \text{ &c.} = \infty \times \infty a = \infty^2 a$ . After the same manner  $0 1 = 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.}$  If substracted perpetually from it self, it becomes  $0 1 - 0 1 + 0 1 - 0 1 \text{ &c.} = 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.} - 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.} - 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.} - 1 - 1 + 1 - 1 + 1 - 1 \text{ &c.} + \text{&c.} =$  (since a perpetual Substraction of a quantity from it self is the same with a Division by  $\infty$ )  $\frac{1 - 1}{+ 1}$

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$$\frac{+1-1+1-1\&c.}{\infty} = \frac{0}{\infty} = \frac{1}{\infty} \times 0 = 0 \times \frac{1}{\infty}$$

$+1-1+1-1\&c. = 0^2$ . Thus we have a relative Nothing less than 0, but of a superior degree, for as *relative infinitely great* Numbers, encrease in their value, by being raised to superior degrees, so *relative infinitely little*, decrease, because the first perpetually ascend from Finite, the Latter *descend* perpetually further from it. And thus all the Degrees that Finite Quantities admit of, may be form'd, from relative Infinites and Nothings. And as we have Indefinites  $\sqrt[m]{\infty}$  between 1 and Infinite in *ascending*, and  $\sqrt[m]{0}$  between 1 and 0, in descending, so *Analogous* to their Natures we have the superior Degrees  $\sqrt[m]{\infty^n}$  and  $\sqrt[m]{0^n}$ . Nature in all these cases admitting of no Bounds nor Limits.

### Definition IX.

*Absolute* or SUPREME Infinite, in a proper Sense, is one, Individual, admitting of neither encrease, nor diminution, or of any Operation that *Mathematical* Quantity is subjected to.

This will be better Understood afterwards.

Defi-

## Definition. X.

*Absolute Nothing* in a proper Sense, is neither capable of encreasing nor diminishing, nor of anywise altering any *Mathematical Quantity* to which it is apply'd, but stands in full opposition to *absolute Infinite*.

## Axioms.

I. That which is greater or less than any possible *Finite Quantity* how great or little soever, must be a *relative Infinite*, *Indefinite*, or *Nothing*, and which of all these Three, the given *Quantity* is, the state of the Case will always determin.

Besides, *Infinite*, *Indefinite*, and *Nothing*, relatively considered, we have no *Idea's* of *Quantity*, and the Definitions of these already given, apply'd to the state of the Case under consideration, will always determine which of these, the *Quantity* assigned must be.

II. *Number* being the simplest Measure of *Quantity*, and a proper *Unity* being the Measure of all *Number*, a proper *Unity* is the Measure of all *Quantity*.

That *Unity*, is the Measure of all *Integers* is evident: And in *Fractions*, the *Denominator* determines the proper *Unity*, whereof

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whereof the *Numerator* determines the Number. Wherefore in the following Propositions instead of Quantity, we shall frequently use it's Measure Number, to express their meaning and to demonstrate their Truth.

### Propositions.

I. *Quantity* may be encreas'd or diminish'd in *Infinitem*.

Case 1. That *Quantity* may be encreas'd in *Infinitem*, is evident from hence, that since it is certain, a Finite *Quantity* may be added to a Finite, what may be once done, may be done again and again, and consequently may be done any Number of Times, greater than any Finite Number how great soever, that is by *Definition 4.* and *Axiom 1.* *Quantity* may be encreas'd in *Infinitem*.

Case 2. That *Quantity* may be diminished in *Infinitem* is evident from hence that out of the given Quantity *AB*, by the *Sixth Book of Euclid*, you may take out any given  $\frac{m}{n}$  Part, and out of the Remainder, you may also take out any  $\frac{m}{n}$  Part, for the same Reason that you can take it out of the first given Quantity *AB*, and so on continually, and yet

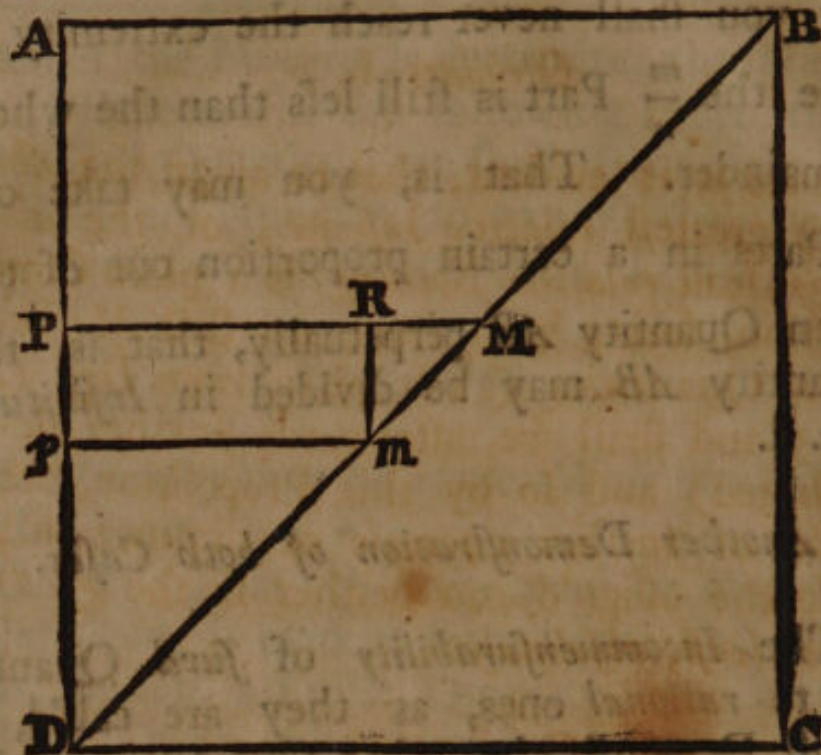
yet you shall never reach the extremity *B*, since the  $\frac{m}{n}$  Part is still less than the whole Remainder. That is, you may take out  $\frac{m}{n}$  Parts in a certain proportion out of the given Quantity *AB* perpetually, that is, the Quantity *AB* may be divided in *Infinitem*. q. e. d.

*Another Demonstration of both Cases.*

The *Incommensurability* of *surd* Quantities to *rational* ones, as they are call'd, is a full Demonstration, that *Quantity* may be increas'd or diminish'd in *Infinitem*.

---

Let



Let  $ABCD$  be a square, whose *Diagonal* is  $DB$ , putting the side  $AD = 1$ . Then is  $AD$ , to  $DB$ , as  $1$  to  $\sqrt{1}$ . Take in the side  $AD$ , apart  $Pp$  the least possible draw  $PM$ .  $pm$  parallel to  $AB$  and  $Rm$  parallel to  $AD$ . Since the Triangles  $BAD$  and  $MRm$  are similar,  $Rm$  will still be to  $mM$  as  $1$  to  $\sqrt{1}$ . therefore it is impossible to find in  $AD$ , a Part how small soever, that taken, any Finite Number of Times, how great soever, shou'd be equal to  $mM$ . So that let  $AD$  be divided into parts how small soever, and how many soever, yet still  $DB$  may be further divided. That is *per Def.* 5. and 4. and *Axiom* 1.  $DB$  may be divided in *Infinitem*, and  $AD$  encreas'd in *Infinitem*.  
q. e. d. Corol-

## Corollary I.

Hence it is evident, that to assign the *absolutely* greatest *relative Infinite*, or the *absolutely* least *relative Nothing* is a plain Contradiction, seeing both these are still *Mathematical* Quantities (as is plain from *Def. 1. 4. & 5* and shall be afterwards further demonstrated) and so by this Proposition, are capable of further encrease or diminution; and so the assign'd can neither be the *greatest* nor *least, absolutely*.

## Corollary II.

Hence, and from *Def. 4. & 5*, we may discover wherein the *specifick* difference between *Finites* and *relative Infinites* or *Nothings* consists: To wit, in the limited encrease or diminution of the former, and in the perpetuity of the encrease or diminution of the latter, for assoon as the encrease or diminution in these latter stops, they become limited and assignable, and consequently *Finite*, and thereby, no part of the desired *Infinite*.

## Corollary III.

Hence it appears, that an Infinite of either sort is (as to all *Arithmetical* Operations on it, with due regard to the perpetuity of its encrease, or diminution,) of the Nature of an *unknown* quantity in *Algebra*. For as in this, from the state of the *Problem*, we perform *Arithmetical* Operations on it, as it were known, and thereby we sometimes do, and sometimes do not determine its value, but by Approximation: So on this, we may perform the like Operations as upon an unknown quantity, with due regard to its particular nature, and the State of the *Problem*, and thereby often discover the *specifick* Genius of its Progression, which is always *Regular* and *Harmonious*, as will be afterwards seen.

## Proposition II.

Unity divided by an infinite number of Unities makes the Quotient *relative Nothing* or  $\frac{1}{\infty} = 0$ .

*Demonstrat.*  $\infty 1 = 1 + 1 + 1 + 1 + 1 \&c.$   
 per Def. 4.  $\& 01 = 1 - 1 + 1 - 1 \&c.$  per  
 Def. 5. divide 1, by  $1 + 1 + 1 + 1 + 1 \&c.$   
 and by the common Operations of *Algebra*,  
 you shall have  $1 + 1 + 1 + 1 + 1 \&c.) 1 (1 -$   
 $1 + 1 - 1 + 1 \&c. = 0. \text{ Q. e. d.}$

Corol.

*Corollary I.*

From hence it is evident, that *Unity* divided by *relative Nothing* is equal to  $\infty$  I. for  $1 - 1 + 1 - 1 + 1 - 1 \&c. = 0$   $1 (1 + 1 + 1 + 1 + 1 \&c. = \infty$  I therefore  $\frac{1}{0} = \infty$ .

*Corollary II.*

Hence also it follows, that  $\infty \times 0 = 1$ . But this may be demonstrated otherwise thus.  $\infty$  I =  $1 + 1 + 1 + 1 + 1 \&c.$  per *Def. 4.* Multiply both by 0 and then it is,  $\infty 0 = 0 + 0 + 0 + 0 + 0 \&c. = 0 \times \frac{1}{\infty} + 1 + 1 + 1 + 1 + 1 \&c.$  but by *Prop. 2.*  $0 = \frac{1}{\infty}$ . and  $1 + 1 + 1 + 1 + 1 \&c. = \infty$ . therefore  $\infty \times 0 = \frac{1}{\infty} \times \infty = \frac{\infty}{\infty} = 1$  q. e. d.

*Proposition III.*

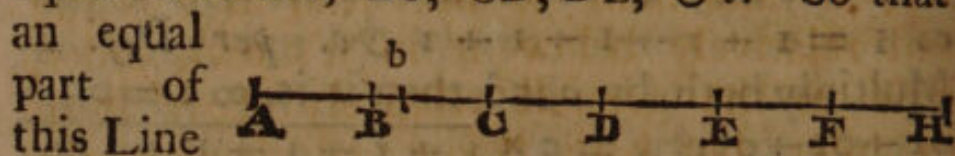
As *Finite* in General is to *relative Infinite* in General, so is *relative Nothing*, to *Unity*. That is  $\ominus : \infty \ominus :: 0 : 1$ .

*Demonstrat.* By 1. *Corollary Prop. 2.*  $\frac{1}{0} = \infty$ . Multiply both by  $\ominus$  then  $\frac{\ominus}{0} = \infty \ominus$  that is  $\ominus 1 = \infty \ominus 0$ . therefore  $\ominus : \infty \ominus :: 0 : 1$ . q. e. d.

Proposition IV.

*Relative Nothing* is a real *Mathematical* Quantity, and implies the least part of the Finite, to which it is related or compared.

*Demonstrat.* This is evident from the Generation of *Relative Nothing*, assign'd in *Def.* 5. But to demonstrate the Proposition, without regard to this Definition, let *AH* infinitely produced from *A*, be divided into equal Parts *AB, BC, CD, DE, &c.* So that an equal



part of this Line may denote any Number. Supposing  $AB = 1$ , let  $x$  denote any Number, for Example  $x = AB$ ,  $y = Ab$  then by the common Rules of Division  $\frac{1}{y-x} = \frac{1}{y} + \frac{x}{y^2} + \frac{x^2}{y^3} + \frac{x^3}{y^4} \&c.$  Now suppose  $b$  infinitely near to  $B$ , then  $y - x = Bb = \dot{x}$  &  $\frac{1}{x} = \frac{1}{y-x}$  but  $x = \dot{x} + \dot{x} + \dot{x} + \dot{x} \&c.$  by *Def.* 4. that is  $x = \dot{x} \times \overline{1 + 1 + 1 + 1} \&c.$  therefore  $\frac{1}{x} = \frac{1}{x} + \frac{1}{x} + \frac{1}{x} + \frac{1}{x} \&c.$  But by Supposition  $AB = x = 1$  therefore  $\frac{1}{x} = 1 + 1 + 1 + 1 + 1 \&c. = \infty 1.$  But by

*Corollary* 1. *Prop.* 2.  $\frac{1}{0} = \infty$  therefore  $\frac{1}{x} = \frac{1}{0}$  and

$\frac{1}{\infty}$  and consequently  $\dot{x} = 0$ . But  $\dot{x}$  being a real *Mathematical* Quantity, by *Def. 1. o.* also must be a real *Mathematical* Quantity, and the least part of Unity to which it stands related or compared. q. e. d.

*Corollary I.*

Since  $\infty$  ascends from the given Finite, in the same manner that  $o$  descends below it, and since  $o$  is a real *Mathematical* Quantity, so also must  $\infty$  be. And as  $o$  is the least relatively below it in it's own order, so is  $\infty$  the greatest relatively above it in it's order, but both below and above these, we may *descend* or *ascend* in a higher order or degree, without Bounds or Limits.

*Corollary II.*

When a *Curve* is said to meet with it's *Asymptot*, and when in the common *Hyperbola*, we obtain the *Area*  $\frac{1}{1-x}$  or in the

Example proposed we put  $y = x$ , in these and such like Cases we mean only, that in the first case the *Ordinate* is infinitely little, in the Second, we mean the least part of the *Absciss*, and in the Third that  $y$  and  $x$  must differ only, by an *infinitely little* part of  $x$ , or by  $\dot{x}$  only; and not that

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they are *absolutely* equal; else there would be no Division, and consequently no Quotient, as shall be afterwards shewn.

### Corollary III.

Since by *Corollary I*, 2d *Prop.*  $\infty = \frac{1}{0} =$   
 $\frac{1}{1 - 1 + 1 - 1 + 1} \text{ \&c.} = 1 + 1 + 1 + 1 + 1$

*\&c.* Since also  $\frac{1}{1 - 1} = 1 + 1 + 1 + 1 + 1$   
*\&c.* as is evident from the common Rules of Division, seeing the Two first Terms only effect the Quotient, (all the rest being but repetitions of the same Terms,) and lastly, seeing the same Quotient is obtain'd whether the Divisor be  $1 - 1$  or  $1 - 1 + 1 - 1 + 1 - 1 \text{ \&c.}$  the reiterated Multiplication of the Quotient upon the Divisor, producing the same effect (in the actual Operation of the Division) which soever of the Divisors we choose, we may safely put in common Cases  $1 - 1$  or  $2 - 2$  or  $a - a$  for  $0$ .

### Corollary IV.

From hence, and *Def. 4.* we may discover the true meaning of the Expression, when it is said a *Quantity* is greater than *Infinite*, or one *Infinite* is greater than another. In these

these and the like Expressions  $\infty 1 = 1 + 1 + 1 + 1 + 1 \&c.$  is always supposed the common Standard or Measure, to which all others are compared. Proper *Unity* being by *Axiom 2.* the common Measure of all Quantity, and when a Quantity  $x$  is said to be greater than *Infinite*, the meaning is, that it may be an *Infinite*, greater than  $\infty 1$ . and when  $\infty 2$  is said to be greater than  $\infty 1$ , it is no more than to say  $2 < 1$ . In all these *relative Infinites* admitting of comparison, there is still a particular *Finite*, to which each respectively are related, and it is on these *Finities* that the comparing the *Infinites* among themselves is founded. Thus

$$\infty 2 = \frac{2}{0} = \frac{2}{1-1} = 2 + 2 + 2 + 2 \&c. \text{ when}$$

compared with  $\infty 1 = \frac{1}{0} = \frac{1}{1-1} = 1 + 1 + 1 + 1 \&c.$  the finite Parts of these Two *Infinites*, *viz.* 2, and 1, are the Subjects of the Comparison. And when  $\infty 2$  is said to be greater than  $\infty 1$ , it means only that the *Finite's* Parts, of which they are Generated, are as 2 to 1, or these in the first are double of those in the second. It is the same thing as in  $\odot 2$ , compared with  $\odot 1$ , or  $2x$  with  $1x$ , nothing is meant in either, but that 2 is greater than 1:  $\odot$ , and  $x$ , and  $\infty$ , being as to this Case, equally unknown Quantities, which may be thrown

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out in the Comparison, and *universally*, in all relative Infinites  $\infty n, = n + n + n + n$  &c. and in all relative Nothings  $o n, = n - n + n - n + n - n$  &c.  $\infty n = \frac{n}{o}$  is the expression of the *Ratio* of the first Series, and  $o n = \frac{n}{\infty}$  is the expression of the *Ratio* of the second Series, and these Two  $\frac{n}{o}$  and  $\frac{n}{\infty}$  are proper Subjects of the comparison, where  $n$  may admit of all the Relations that Finites have among themselves.

*Proposition V.*  $\frac{s}{1} = \frac{s}{o} = c \infty$

*Relative Infinites, Indefinites, and Nothings* (with the proper Limitations peculiar to each) admit of all the Degrees and *Arithmetical Operations*, that Finite or *Mathematical Quantities* are subjected to.

*Demonstrat.* This is evident from *Def.* 4, 5, and 6. and the *Scholia* adjoining to these, and is also manifest from the precedent *Prop.* and it's first *Corollary*, as to relative Infinites, and Nothings; and shall be afterwards shown, as to Indefinites, to wit, that all these are still *Mathematical Quantities*, capable of Increase and Diminution in *Infinitum*, and consequently must admit

admit of all these *Arithmetical* Operations (with proper Limitations peculiar to each) that finite Quantities are subjected to. And to confirm this, we may observe in *Nature*, a resemblance of these higher Degrees of *relative Infinites*, and consequently by *Analogy*, of *relative Nothings* also. For if *Space* be *Infinite*, as shall be afterwards Demonstrated, it must be supposed equal to an infinite *Cube* or *Sphere*, whose *Diameter* will be as  $\infty$  1, it's *Section* through this *Diameter* as  $\infty^2$ , and it's *Content* as  $\infty^3$ . q. e. d.

*Proposition VI.*

*Relative Infinite* has, to the *Finite* with which it is compared, no finite Proportion, or *Finite* when compared with it's proper *relative Infinite* becomes *relative Nothing*.

*Demonstrat.* This is evident from 4 *Corollary Prop. 4.* the *Ratio* of the *relative Infinites* in general  $\infty n = n + n + n + n \&c.$

being  $\frac{n}{0}$  that is  $\infty n = \frac{n}{0}$  therefore  $\infty n :$

$n :: 1. 0. q. e. d.$  on the other side let us suppose the *Ratio* of the *relative Infinite* in general  $\infty n$  to  $n$ , to be a finite *Ratio*  $\frac{s}{r}$

then  $\infty n = \frac{r}{s}$  which is impossible by 2 *Co-*

*rollary*

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rollary Prop. 3. wherefore since  $\infty n : n :: 1 : 0$  by composition of Ratio's,  $\infty n + n : n :: 1 + 0 : 0$  but  $1 + 0$  is but  $1$ , therefore  $\infty n + n$  is but  $\infty n$ , or  $n$  a finite Quantity when compared with it's relative Infinite  $\infty n$  becomes  $0$ . q. e. d.

*Corollary I.*

Hence, *relative Infinite* in General, is to *Finite* in General, as *Unity* is to *relative Nothing*: or any *Finite*, when compared with *relative Infinite* in General, becomes *relative Nothing*: that is  $\infty : \ominus :: 1. 0$ .

*Demonstrat.* By the precedent Proposition  $\infty n : n :: 1 : 0 :: a : 0 a$ , and by conversion of ratio's  $\infty n : a :: n : 0 a$ . Supposing then  $a$  to be a *Finite* quantity, nothing but an Infinite number of relative Nothing or  $o$ 's being equal to  $1$ , by *Corollary 2. Proposition 2.*  $0 a$  must be still  $0$ , or  $a - a + a - a + a - a \&c. = 0$ , by *Corollary 3. Proposition 4.* wherefore  $\infty n : a :: n : 0$ , and by Composition of ratio's  $\infty n + a : a :: n + 0 : 0$ , put  $n = 1$  and  $a = \ominus$  then  $\infty + \ominus : \ominus :: 1 + 0 : 0$ : and since  $1 + 0$  is but  $1$ , therefore  $\infty + \ominus$  is but  $\infty$ ; wherefore  $\infty : \ominus :: 1 : 0$ , or when any *Finite* is compared (by Addition, (or by Subtraction by Division of ratio's)) with *relative Infinite* in General, it becomes *relative Nothing* q. e. d. The true *Analogy* is this,

$\infty n$

$\infty n$  or  $n + n + n + \&c.$   $a :: n : a - a + a - a + a - a \&c.$  but because  $a$  is supposed Finite,  $a o$  is the same (in Cases of Addition and Subtraction) with  $o$ . But were  $a = \infty 1$ , then  $a - a + a - a + a - a \&c.$  wou'd be  $\infty - \infty + \infty - \infty + \infty - \infty \&c. = \infty \times 1 - 1 + 1 - 1 + 1 - 1 \&c. = \infty \times 0 = 1$ , and  $\infty n - \infty n + \infty n - \infty n \&c. = \infty^n = n$ .

*Corollary II.*

Put  $n$  equal to any Integer, then  $\infty^{n-1} : n :: 1 : o$ , but  $o^n : o^{n-1} :: o : 1$ , for the first being reduced, becomes  $\infty : 1 :: 1 : o$ , and the second being reduced, becomes  $o : 1 :: o : 1$ ; and therefore when  $\infty^{n-1}$  is to be added to, or subtracted from  $\infty^n$ , it becomes  $o$ ; and when  $o^n$  is to be added to, or subtracted from  $o^{n-1}$  it becomes also  $o$ , by *Scholium Def. 6.* and the Case is the same when the Inferior Powers suppose  $\infty^{n-2}$ , or  $\infty^{n-3} \&c.$  are to be added to, or subtracted from  $\infty^n$ , or when  $o^n$  is to be added to, or subtracted from the Inferior Powers  $o^{n-2}$  or  $o^{n-3} \&c.$  in all such cases its evident from the precedent *Prop.* and its *I. Corollary*, that  $\infty^{n-2}$   $\infty^{n-3}$  and  $o^n$  become  $o$ .

*Scho-*

*Scholium.*

From these *Propositions* and *Corollaries*, an *Aritmetick* of Infinites may be drawn out, different from any hitherto published, of no contemptible use, or narrow extent in *Algebra*, and *Geometry*; as will be in some measure shown by the Third Chapter.

*The Aritmetick of Infinites.*

**A**ddition.  $2 \infty + 3 \infty = 5 \infty$ .  $a \infty + 2 a \infty = 3 a \infty$ .  $\infty^2 + 2 \infty^2 = 3 \infty^2$ .  
 $\infty^n + p \infty^n = \overline{1+p} \infty^n$ .  $a \infty + e \infty = \overline{a+e} \infty$ .  
 $3 \infty + 10 = 3 \infty$ .  $a \infty + a = a \infty$ .  
 $\infty^2 + \infty = \infty^2$ .  $\infty^n + \infty^{n-1} = \infty^n$ .  
 Let  $q$  be less than  $n$ , by a finite Integer, then  $\infty^n + \infty^{n-q} = \infty^n$ .

Substraction.  $5 \infty - 2 \infty = 3 \infty$ .  $10 a \infty - 3 a \infty = 7 a \infty$ .  $6 n \infty - 4 n \infty = 2 n \infty$ .  
 $5 \infty - 7 \infty = -2 \infty$ .  $7 \infty^3 - 5 \infty^3 = 2 \infty^3$ .  
 $9 \infty^p - 5 \infty^p = 4 \infty^p$ .  $5 \infty^p - a \infty^p = \overline{5-a} \infty^p$ .  
 $3 \infty - 7 = 3 \infty$ .  $a \infty - a = a \infty$ .  $\infty^p - \infty^{p-1} = \infty^p$ .  
 Let  $q$  be an Integer, less than  $p$ , then  $\infty^p - \infty^{p-q} = \infty^p$ .

Multiplication.  $\infty \times 3 = 3 \infty$ .  $\infty \times a = a \infty$ .  
 $\infty \times \infty = \infty^2$ ;  $\infty^2 \times \infty^3 = \infty^5$ .  $\infty^p \times \infty^q = \infty^{p+q}$ .  
 $a \infty \times e \infty = a e \infty^2$ .  $3 \infty$   
 $a \times$

$$a \times 4 \infty x = 12 \infty^2 a x. \quad - 2 \infty x - 3 \infty$$

$$= 6 \infty^2. \quad - \infty a x + \infty = - \infty^2 a.$$

Division.  $\frac{\infty}{2} = \frac{1}{2} \infty.$  or  $\infty \frac{1}{2} = \frac{\infty a}{e} = \infty$

$$\frac{a}{e} \cdot \frac{2 \infty}{\infty} = 2. \quad \frac{3 \infty}{4 \infty} = \frac{3}{4} \cdot \frac{\infty a}{\infty e} = \frac{a}{e} \cdot \frac{\infty 2}{\infty} = \infty.$$

$$\frac{\infty 3}{\infty} = \infty^2. \quad \frac{\infty p}{\infty q} = \infty^{p-q}. \quad \frac{+ 3 \infty}{- \infty} = - 3. \quad \frac{- 4}{- 2}$$

$$\frac{\infty}{\infty} = + 2. \quad \frac{- \infty a}{+ \infty e} = - \frac{a}{e}.$$

Fractions.  $\infty \frac{2}{3} + \infty \frac{4}{5} = \infty \frac{22}{15} \cdot \infty \frac{a}{e} +$

$$\infty \frac{p}{q} = \infty \frac{aq + ep}{eq}. \quad - \infty \frac{3}{2} + \infty \frac{4}{5} = \frac{2}{15} \infty.$$

$$\infty \frac{a}{e} - \infty \frac{p}{q} = \infty \frac{aq - ep}{ep}. \quad \infty \frac{a}{e} \times \infty \frac{p}{q} =$$

$$\infty^2 \frac{ap}{eq} \cdot \infty \frac{a}{e} \left( = \frac{ep}{qa} \cdot \infty \frac{5}{4} \right) \infty \frac{2}{3}$$

$$\left( = \frac{8}{15} \right)$$

Those who are ever so little acquainted with the *Specious Arithmetick*, will easily understand the reason and Truth of these Operations.

*Proposition VII.*

*Indefinite Quantities* are not properly either Finite or Infinite, but between both.

*Demonstrat.* An Indefinite Quantity is some mean Proportional, between Finite and relative

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lative Infinite, *per Def.* 6. that is, one of those Infinites will be  $\infty = \sqrt{\infty} \ominus$  put  $\ominus = 1$ , and then  $\sqrt{\infty}$ , will be an Indefinite Number, now this  $\sqrt{\infty}$  can neither be Finite (and this manner of reasoning will hold good of any other Indefinite whatsoever) nor Indefinite, not Finite, else  $\ominus$  would be Infinite, which is impossible; nor Infinite, for the least possible Infinite, must be Infinite in general, divided by the greatest possible Finite  $x$ , and then if  $\sqrt{\infty}$  be Infinite,  $\sqrt{\infty} = \frac{\infty}{x}$  and  $x^2 = \frac{\infty^2}{\infty} = \infty$ , which is also absurd. Again if  $\sqrt{\infty}$  be Infinite, then is  $\infty \times \frac{1}{\sqrt{\infty}} (= \sqrt{\infty}) = \text{Infinite}$ , and  $\frac{1}{\sqrt{\infty}} =$  to it's relative Infinitely small part, or it's relative Nothing  $= 0$ , and so  $\infty \times 0 = \infty \times \frac{1}{\sqrt{\infty}} = (\sqrt{\infty} =)$  to Infinite. But by *Corollary 2. Prop. 2.*  $\infty \times 0 = 1$ , and instead of  $\infty \times 0$ , putting it's value 1. in this last equation, it will be  $\infty \times 0 = 1 = \infty \times \frac{1}{\sqrt{\infty}} = \text{Infinite}$ , by supposition; and this supposed Infinite would become 1, which is absurd. q. e. d.

*Scholium.*

Taking the instance of the Indefinite quantity proposed  $\sqrt{\infty} \cdot 1 = \sqrt{1 + 1 + 1 + 1} \&c.$  It's plain the root of any given number grows Greater or Less, as the number expressing or denominating the root is Less or Greater; and in  $\sqrt{\infty} \cdot 1$ , it's infinitely little root or  $^{\infty}\sqrt{\infty} \cdot 1$  may be any finite Number greater than Unity as has been already shown; and its infinitely great root or  $^1\sqrt{\infty} \cdot 1$  is Infinite. And between these Ly all the Indefinites that can be formed on 1 and  $\infty$ ; to wit,  $^2\sqrt{\infty}$ ,  $^3\sqrt{\infty}$ ,  $^4\sqrt{\infty}$ , &c. and none of these can be properly called either, Finite or Infinite, but are in a perpetual Gradation towards either of these extremes, as the number that denominates the root grows greater or less; and they never become actually Finite, but when the number denominating the root is actually Infinite, nor actually Infinite, but when the Number denominating is *Unity*. And between these Two *Limits*, they are neither actually Finite not Infinite. Next to  $^1\sqrt{\infty} = \infty$  (in order of the simplest Indefinites,) is  $^2\sqrt{\infty} = 1 + \frac{1}{2} + \frac{3}{\infty} + \frac{5}{16} + \frac{35}{128} \&c.$  wherein (by the quick encrease and greatness of the succeeding terms) the last becomes  $\frac{1}{\infty}$  in a few Number, so to speak, of these terms,

terms, where the series terminates, and so their sum  $\sqrt[2]{\infty}$ . becomes thereby less than  $\infty$  1. as will be more fully explain'd in the following Chapter, and in  $\sqrt[5]{\infty}$  (for example)  $= 1 + \frac{1}{5} + \frac{6}{30} + \frac{66}{750} \&c.$  we see the terms of the Series converge yet faster, and will thereby terminate at  $\frac{1}{\infty}$ , much sooner. And so their sum  $\sqrt[5]{\infty}$  will be much less than  $\sqrt[2]{\infty}$ . And for these (even when they rise to fractional Exponents whose Numerators are greater than 1, Such as  $\infty^{\frac{2}{3}}$ .  $\infty^{\frac{3}{4}}$ .  $\infty^{\frac{4}{5}}$  &c.) an *Arithmetick* may formed, according to the example laid down in the *Scholium* of the precedent Proposition, with this ad-

dition, that an Indefinite as  $\infty \frac{q}{p}$  or  $p \sqrt[5]{\infty} q$  multiplied by another Indefinite  $\infty \frac{r}{s}$  gives the Product  $\infty \frac{q}{r} + \frac{r}{s}$  which becomes Infinite, when  $q s + p r$  is  $=$  or  $<$   $p s$  and Indefinit when  $q s - p r$  is  $=$  or  $>$   $p s$ .

And if an Indefinite as  $\infty \frac{q}{r}$  be divided by an Indefinite, as  $\infty \frac{r}{s}$  the Quotient  $\infty \frac{q}{p} - \frac{r}{s}$  is Infinite, when  $q s - p r$  is  $=$  or  $<$   $p s$  but is Finite when  $q s - p r = 0$  and only Indefinite, when  $q s - p r > p s$ . as

it ought to be according to the Arithmetick of Surds.

*N. B.* That in expressing an Indefinite by  $\infty \frac{q}{p}$  it is always supposed that the Number  $q$  is less than  $p$ , for if  $q$  be either greater or equal to  $p$ , then  $\infty \frac{q}{p}$  tho' it may be an Indefinite, of the superior Degrees, yet it is always Infinite in it's value.

*Proposition VIII.*

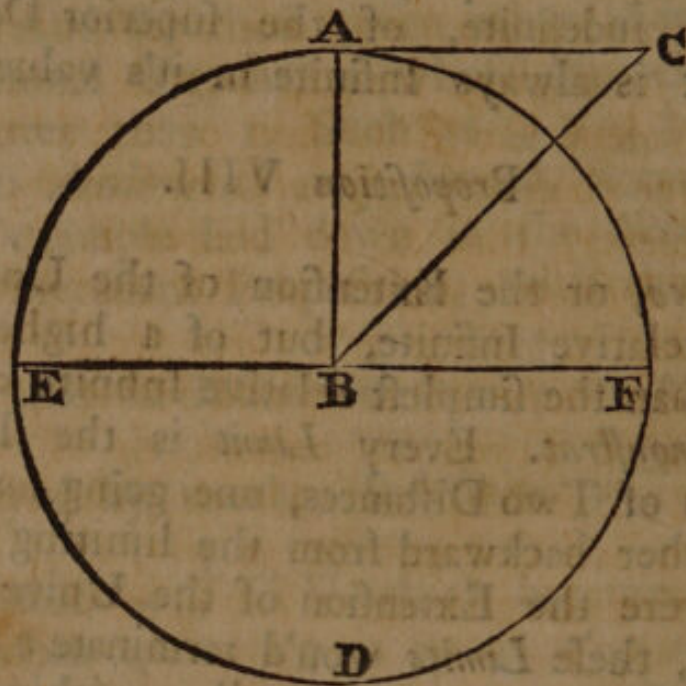
*Space*, or the Extension of the Universe, is a relative Infinite, but of a higher Degree than the simplest relative Infinite  $\infty 1$ .

*Demonstrat.* Every *Limit* is the Termination of Two Distances, one going forward, the other backward from the limiting Point, and were the Extension of the Universe limited, these *Limits* wou'd terminate a *Space*, beyond these *Limits*, as well as within them. That is, either the universal *Space* must be unlimited, and consequently Infinite, or there must be *Space* beyond the *Limits* of universal *Space*, which is absurd. Again, if the Extension of the Universe were limited any way, so as to become Finite, then a *Sphere* of a finite *Diameter*, might be found equal to it. For a *Cube* of a Finite side, may be found equal to any Finite *Content* what-

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soever,

soever, as is well known, and the *Radius* of a *Sphere* equal to this *Cube*, is the *Product* of the *side* of the *Cube*, multiplied into the *Cube Root* of  $\frac{2}{3}$  parts of the *Ratio*, of the *Radius* to the *Circumference*. Let us suppose the whole finite *Extension* of the *Universe* equal to the *Sphere* whose *Radius*



is *AP*. Let this *Sphere* be cut by a *Plane* through it's *Center*, and the *Section* be the *Circle* *ADFE*, it is certain from the *Elements* of *Euclid*, that to any given *Point* *A*, a *Tangent* *AC* may be drawn, of which only the *Point* *A* falls upon the *Circle*; the rest of the *Line* *AC* falling without it. From whence it is evident, that there must be *extension* without this *Circle*, or the *Sphere*

*Sphere* by the Section of which it is Generated. Since a *Plane* passing through this *Tangent*, and perpendicular to the *Plane* of this *Circle*, will only touch the *Sphere* in a *Point*; by which there will be an extended distance remaining between the *Circumference* of the *Sphere*, and the *touching Plane*, in all their *Points* excepting that one at *A*; And since this is true of every *assignable* Extension how great soever, less than Infinite: It is evident the Extension of the *Universe* is greater than any *assignable* Extension, how great soever, that is, by *Axiom* 1. it is *relatively Infinite*, which is still more evident from *Def.* 4. Since it's parts are *Finite* and their *Sum* only *Infinite*, and seeing this *Infinite* is of *Three* Dimensions, or as  $\infty$  1 in *Height*, *Breadth*, and *Depth*, therefore it must in it's *Content* be as  $\infty^3$ , that is, of a superior *Degree* to  $\infty$  1. q. e. d.

## C H A P. II.

Of the PHILOSOPHICAL  
Principles of Reveal'd Religion.

## Lemma I.

THERE is in all the Works of Nature, a *Symmetry*, and *Harmony*, running on in a perpetual *Analogy* (with proper *Limitations* arising from the different *Circumstances* of the several *Parts*) through the whole and the parts, or there is a *regular Connexion*, and *uniform Proportion* between similar *Causes* and *Effects*, a *Congruity* between the *End* and the *Means*. An *Aptitude* between the *Faculty* and it's *Acts*, and between the *Organs* and their intended *uses*, in the whole, and in the several parts of this *System* of things.

*Demonstrat.* This is evident from innumerable *Instances* already discover'd and ascertain'd. And every new *Discovery* in the most minute part of the Works of Nature, carries along with it a fresh *Demonstration* of this *Proposition*; one must be intirely ignorant of *Philosophy*, and *Mathematicks*, to want a *Cloud* of *Witnesses* to this *Truth*.

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For Instance, the *sesquialter* Proportion, of the Periodical times of the Revolutions of the *Primary Planets*, about the *Sun*; and of the *Secondary Planets*, about the *Primary ones*; to their *middle Distances*, from the *Sun* and *Primary Planets* respectively, obtains univerversally. Their *Magnitudes*, *Gravities*, *Densities*, and their *Velocities* in their *Orbits*, in respect to, and about the *Sun*, and the *Primary Planets*, in the *Planets*, *Comets*, and *Satellites*, are in a regular and comely Proportion; the same *Gravity*, the same *Law* thereof, and the similar effects of both, obtains through the whole material *System* of things. The *Reflexions*, *Inflexions*, and *Refractions* of *Light*, are the same, in all the *Planetary* and *Cometary* Bodies and *Regions*; as they are on our *Terrestrial Globe*, with due regard to the different *Densities* of the *Mediums*. The *Circulation* of the *Fluids*, the *Manner*, and *Organs* of *Respiration*, and *Generation*, are *Analogically* the same in *Man*, *Brutes*, and *Vegetables*; with proper *Limitations* arising from the differing *Circumstances* of these *Gradations* of *Animals*. The *general Laws* of *Fluids*, *Elasticity* and *Gravity*, obtain in *Animal* and *inanimate Tubes*, but so far as they are alter'd in the first, by *Collateral Causes*. The whole of *Philosophy* and *Mathematicks*, is nothing but particular *Instances* of this Beautiful

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*Analogy*, and the preceeding Chapters of the *first Part*, contain nothing but particular Instances thereof. And if we descend into the *Spiritual World*, we shall find this Beautiful *Analogy* preserv'd, as far as the different Circumstances of these Beings will permit. And if in this Demonstration, it were allow'd to take in the Supposition of a *Being infinitely perfect*, who contrived and executed the whole, and the several Parts of this *System* of Things; it is impossible it shou'd be otherwise: A Being infinitely Wise, Simple, and One, must necessarily bring about Similar Ends by Similar Means, and perform all his Works the plainest, most Simple, and shortest way possible, due regard being had to the whole and the different Circumstances of the several Parts. *Wisdom in Things*, is their *Symmetry*, *Regularity*, and *Aptitude* for obtaining their design'd Ends and Purposes. The *Wisdom* of a *Machin*, consists in the due proportioning of the several Parts to one another, and to the whole, for obtaining it's propos'd End. *Disproportion*, *Irregularity*, *Discord*, and the having no View or Design, are the surest Proofs, and Indications, of Chance, Impotence, and Folly: A Wise Man performs all his Works, in Number, Weight, and Measure, and sure *infinite Wisdom*, *Simplicity*, and *Unity*, must accomplish all it's Works, with the most

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*Consummate Harmony, Proportion, and Regularity.* And this is the following Parts of this Treatise for Brevities sake, we shall call the ANALOGY OF THINGS.

Lemma II.

This ANALOGY OF THINGS duly instituted, is as certain a *Demonstration* of the *Existence*, and *Wisdom* of the Author of these Things, and of the Contriver of this *Analogy*, as also of the true Nature and Qualities of these Things discovered by this *Analogy*, as any *Mathematical Demonstration*, is of the Proposition proposed.

*Demonstrat.* No effect can be, without it's proper Cause, a wise and regular Effect must be produced by a wise and intelligent Cause, and an *infinitely Wise*, and *infinitely complicated* Effect, must necessarily imply an *infinitely Wise*, and *Omniscient* Cause. These are so certain and infallible *Axioms*, that I know not if in all the Compass of Humane Knowledge, any others come up to the same Degree of Evidence: And he can be no proper Subject of *Philosophy* or *Mathematicks*, who cou'd seriously deny them, since the whole Evidence of both these Sciences, suppose the first of these *Axioms*, and the rest are but like multiplying both sides of the same *Equation* by the same terms.

I have already observed, that the *Wisdom* of an *Effect*, or System of Effects, consists in the Proportion or *Analogy* of the several Parts to the whole and to each other, and of the whole, to the end propos'd; and that irregularity and no Proportion, is the surest Evidence of Want of Contrivance, Wisdom and Design. Now since the ANA-  
LOGY OF THINGS, just now Demonstrated, to be found in all the Works of Nature, in the whole, in every the most Minute Part: And in these, Instances of this *Analogy*, without Number, and without End. (Every new Step in the Knowledge of Nature discovering fresh Instances of this *Analogy*) all these, I say, do necessarily infer, an *infinity of infinitely Wise* Effects; and therefore these Effects, must as necessary infer the Existence of the *Author* of these Effects, and the Wisdom of the Contriver of this *Analogy*, as an Effect infers it's Cause; that is, as certainly as any *Mathematical* Demonstration infers it's Proposition; since it's certainty depends on the Connexion between Causes and Effects, and the Truth of this *Analogy* in general. I say in the next place, that the true Nature and Qualities of these Effects or Things, discovered by this *Analogy*, duly Instituted, may be as certainly concluded from this *Analogy*, as any *Mathematical* Demonstration, concludes

concludes its Proposition. *Mathematicks* and *Philosophy*, so far as they are just and genuine, are but Branches of this *Analogy*. *Mathematicks* are but this *Analogy* apply'd to *Figures* and *Numbers*. *Philosophy*, properly so call'd, is but this *Analogy* apply'd to *Bodies*, or *Systems* of these; or to the abstracted *Natures* of Things. Both, suppose the *Truth* and *Necessity* of this *Analogy*, without which they are but *Fargon* and *Romance*. An Instance or Two will make the whole Matter clear. Suppose it were required, to find the *refracted Ray*, when the *refractive Powers* of the Two *Mediums*, with the *Inclination* of the *incident Ray* on the *incident Plane*, are given. Let us borrow a *Corollary* from this *Analogy* of Things, to wit, that the distance between any fix'd Point in the *Incident*, and another in the *refracted Ray*, (the *refractive Powers* of the Two *Mediums* being regarded,) is the shortest possible; and with this *Corollary*, make an exact *Computation*; we shall then find the *refracted Ray* precisely the same with that found out, from other different Principles and Methods (suppose of *Trigonometry*) where this *Corollary* has had no place, as the *Geometers* have shown. This *Physical Demonstration* of this particular property of *Light*, (to wit, that in all *Incidences*, the *Sine* of the *Angle* of *Incidence*,

is to that of *Refraction*, in a constant *Ratio*) arising from this *Analogy*, is as certain a Proof of the Existence, and Wisdom of the *Contriver* of this *Analogy*, as also of the true Nature of Light, (as to this particular property) as any *Mathematical Demonstration* (suppose that by *Trigonometry*) is of the true Nature of the *incident* and *refracted Ray*. For who but an *omniscient Artificer*, cou'd contrive Light so? That among all the infinitely different possible ways, between Two assign'd Points, it shou'd single out that one, which is the shortest? And it is certain that the *refracted Ray*, is as truly found out by Virtue of this *Analogy*, as by any other more *Geometrical Method*. Another Instance may be taken from the regular and harmonious Progressions of *infinite Series's*; for Example, in the Powers of the *Binomial Root*,  $(a + y)^n = a^n + n a^{n-1} y + n \times \frac{n-1}{2} a^{n-2} y^2 + n \times \frac{n-1}{2} \times \frac{n-2}{3} a^{n-3} y^3 \text{ \&c.}$  or the *Series* produced by Division  $\frac{1}{1-n} = 1 + n^2 + n^3 + n^4 \text{ \&c.}$  In a Word, every particular *Problem* in *Algebra* and *Geometry*, might be brought as Instances of this beautiful *Analogy* of Things, and those who are conversant in the more abstruse Speculations of *abstract Geometry*, can furnish themselves with Instances, so surpris-

surprizing and extraordinary, of the Constancy of Nature in this beautiful Harmony, and comely Proportion, even in the largest Computations and most complex Constructions, as far surpass these Instances I have brought. Now what but an infinitely wise Being, cou'd have constituted the *Intellectual Species* of Things, so admirably? That all the Terms of these Progressions shou'd thus go on in such regular and harmonious Proportions that every succeeding Term shou'd be made up of the preceeding ones, modify'd after one constant way, that by the cast of an Eye, the said succeeding Term shou'd be assign'd? whereas they might have been ordered, other infinitely different ways, so as to have afforded no regular Progression. And does not this *Analogy* and harmonious Progression of these *Series's*, as certainly give the succeeding Terms, as the actual Operations of *Algebra* do? Many more, and yet infinitely more surprizing Instances of this beautiful, *Analogy* and of the Inferences drawn from those assign'd, might be given. But these may suffice for an Illustration of this *Lemma*.

*Lemma III.*

The Rules which seem naturally to arise for the due Institution of this *Analogy* of Things,

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Things, may be reduced to these Three, 1. That the Quality, Property or Idea, on which the *Analogy* is Instituted, be as simple and one, as possibly may be; and intirely the same, both in the known and unknown Subjects of the *Analogy*. Thus when we reason from the Nature and Properties of *Light*, and *Gravity*, on our *Earth*, to the Nature of *Light*, and *Gravity* in the *Planets* and *Comets*. We must separate these into their most simple *Ideas* and *Properties* (to avoid Confusion) as much as may be, and Institute an *Analogy* for each, to discover if the *Analogy* hold good in the complex, and precisely keep to the same *Properties* in the *Planets* and *Comets* the unknown Subject of the *Analogy*, as were supposed in the *Earth*, the known subject of the *Analogy*. Else we shall run into Confusion and *Paralogism*. 2. The necessary Limitations arising from the different Circumstances of the Two Subjects of the *Analogy*, as far as they may be known, must be cautiously and carefully taken into the State of the Question. Thus in the first Instance, assign'd in the Second *Lemma*, if the different *refractive Powers* of the Two *Mediums*, had not been precisely entered into the *Equation*, the Conclusion must have prov'd different from that found out by other Methods. Thus also in reasoning from the manner of *Generation* in *Animals* to that of  
Vege-

*Vegetables.* If the Limitations arising from the different Circumstances, and orders of Being, in these Two Subjects of the *Analogy*, be not carefully taken into the reasoning, the Conclusions must prove false and erroneous. 3. Both the Subjects of the *Analogy* must be known and examined into, as far as may be, in regard to the other Qualities different from those, the *Analogy* is instituted upon: But especially the known Subject of the *Analogy* must be as fully known as is possible, in regard to those Properties, on which the *Analogy* is instituted. Thus the more fully we understand the Nature and Qualities of our *Globe*, especially as to *Light* and *Gravity*, and of the *Comets* and *Planets* as to their other Qualities, the more full and perfect shall our Conclusions be in regard to these assign'd Qualities, in the *Planets* and *Comets*: The more fully we understand the Circulation of the Fluids in *Animals*, the more aptly shall we apply them to *Vegetables*. These Rules duly observed will render the Conclusions drawn by Virtue of this *Analogy of Things*, as certain as any *Mathematical* Demonstration whatsoever.

Proposition IX.

The *Visible*, *Intellectual*, and *Created Species* of Things, are Pictures, Images, and Representations, of the *Invisible*, *Architypal*, and

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and *Increated Species* of Things in the Mind of the supreme Being.

*Demonstrat.* This is evident from *Lemma* 1. and 2. For since it is certain, that there are to be found in all the Works of Nature a beautiful Harmony, a comely Proportion, and an exact Symmetry running thro' the whole. And since this *Analogy of Things*, necessarily infers the Existence of the Author of these Things, and the Wisdom of the Contriver of this *Analogy*. These Things and this *Analogy*, cou'd come from nothing else but from their original *Ideas* and *Architypal Patterns*, in the *Divine Mind* or *Imagination*, and their Harmony and Proportion, can possibly arise from nothing but their being Representations of his *Ideas*, who is omniscient, and does every thing in *Number*, *Weight*, and *Measure*. There being no other possible way they cou'd be contrived; and he being *Supreme* and *One*, cou'd find nothing without himself that they should represent. Besides, it is absolutely impossible, that infinite Power and Perfection, shou'd bring any thing into Being, that had not his own *Signature*, Stamp, or Image on it, for there cou'd be nothing besides *himself*, whose Images they shou'd be; and it is absurd to imagine they shou'd represent nothing at all. Therefore of necessity, they must be Pictures, Images, and Representations

tions of their *Ideas* and original Patterns, in the Mind of the Supreme Being. q. e. d.

*Corollary I.*

Hence it is evident that the *Visible, Intellectual, and Created Species* of Things, are Images, Pictures, and Representations of the *Divine Attributes*, more or less perfect, according to their Order in the rank of Beings. For since they are Images of the *Archtypal Ideas* in the *Divine Mind*, or *Imagination*, and since there was nothing without him, to beget these *Ideas*, and Nothing but his own infinite Perfections, that cou'd represent themselves to him, in order to make these *Ideas* arise in his Mind. Therefore of necessity, they must represent his *Attributes* or *Perfections* the only thing he cou'd have to copy out.

*Corollary II.*

Hence it is evident, that with proper Limitations arising from the *Infinitely-infinite* distance; (so to speak) between Finite and *absolute Infinite* we may reason *Analogically* from the Nature and Attribute of the *Supreme intelligent Being*, to the Nature and Properties of *Finite intelligent Beings*; and from these to those; to wit, by supposing these

these

these last Images, Pictures, and Representations at an infinite Distance of the first.

*Proposition X.*

A *Mathematical Point*, and infinite Space are the Two *Limits* of natural or created Things, as to Quantity or Extension, in Ascending or Descending from Finite. And neither of them is any Part or Multiple of the other.

*Demonstrat.* This is evident from *Prop.* 8. for natural or material Things can have no more Dimensions than Three, and therefore the biggest Extreme in Created things, can rise no further by the *Analogy* of things than to  $\infty$  raised to the Third Dimension. And since infinite Space is as  $\infty^3$ , therefore infinite Space is the biggest Extreme, or Limit of natural Things ascending from Finite. And since a *Mathematical Point* is the surface (so to speak) of the Extremity of a *Mathematical Line*, which has but one Dimension, it must of necessity be the least Extreme, in descending from Finite: In a Word, we can rise no higher in natural and material things than infinite Space, since that is the *Locus Universalis* of all created Beings. And we can descend no lower than a *Mathematical Point*, since every thing below it (if possible) cou'd have no place at all, or wou'd be no where, that is, wou'd be absolute Nothing. And  
neither

neither of them can be any Part or Multiple of the other, since no number of Points, no not even an infinite Number, can make any real natural Quantity, not so much as a *Mathematical Line*, therefore &c. q. e. d.

*Corollary I.*

Hence a *Mathematical Point* and *universal Space* are true and genuine Opposites in Nature, and in the *Analogy* of Things, and between these Two Ly all created finite Subsistences. No natural Thing can be bigger than *infinite Space*, and no natural Thing can be less than a *Mathematical Point*, they differ the most widely that natural Things possibly can, and have nothing common but *Entity*, and so are true and genuine Opposites.

*Corollary II.*

Hence in the *Analogy* of Things, *Matter* cannot be Infinite, in any sense of Infinite ascending from Finite. For since *Matter* is of those natural Things, that necessarily require all the Three Dimensions, were it Infinite, by the *Analogy* of Things, it wou'd necessarily be as  $\infty^3$ , that is, it wou'd be equal to infinite Space, but since the necessity of a *Vacuum* has been Demonstrated in

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the first Chapter of the first Part, it cannot be equal to infinite Space, and since it cannot be Infinite any wise but as infinite Space, by the *Analogy* of Things. Therefore *Matter* cannot be Infinite, in any sense of Infinite ascending from Finite.

Proposition II.

*Absolute Nothing*, upon a real Quantity produces no Effect at all. Or *Absolute Nothing* can be susceptible of none of these *Arithmetical Applications*, to which, real Quantities are subjected.

*Demonstrat.* Suppose absolute Nothing upon a real Quantity, cou'd produce any Effect. Let the real Quantity be  $a$  and the Effect  $m$ , then absolute Nothing  $\times a = m$  that is, absolute Nothing is equal to  $\frac{m}{a}$ , that is, absolute Nothing is a real Quantity, as  $\frac{m}{a}$  is, which is absurd. Now since absolute Nothing multiplied into a real Quantity can produce no Effect, for the reason and by the Argument now assign'd, neither can it, when divided by a real Quantity, by the same way of reasoning, since Division by  $a$ , is the same with Multiplication by  $\frac{1}{a}$ . And since, Multiplication and Division are the same

same with Addition and Substraction reiterated as often as the Multiplier and Divisor implies: Therefore *absolute Nothing* is susceptible of none of those *Arithmetical Applications* that real Quantities are subjected to. q. e. d.

*Corollary.*

*Absolute Nothing* therefore, when apply'd to real Quantities by Multiplication and Division (and consequently, when by Addition and Substraction) implies, that there is neither Product nor Quotient, *that is*, that the real Quantity is neither Multiplied nor Divided, but remains unaltered.

*Proposition XII.*

In the *Analogy* of Things; as a *Mathematical Point* is to *universal Space*, so is *absolute Nothing* to the *absolute and supreme Infinite*.

*Demonstrat.* By Prop. 10. a *Mathematical Point*, and *universal Space*, are the Two *Limits* of material or natural Things: they involve simple, clear, and distinct Ideas, and are as well known, as any of the Objects of Human Knowledge. *Absolute Nothing* is one of the *Limits* of the *Universitas rerum omnium*, to wit, that in descending, be-

low which nothing can fall; and therefore by the Rules laid down, for the *Analogy* of Things, the *absolute* or *supreme Infinite* must be the other Limit, beyond which nothing can rise in Ascending, and between these Two, all *Subsistences*, Finite, Indefinite, and relative Infinite are concluded. Wherefore by *Lemma 3.* and *Prop. 9.* as a *Mathematical Point*, &c. q. e. d.

Corollary I.

Hence *absolute Infinite* can neither be encreas'd nor diminish'd. For *absolute Infinite* and *absolute Nothing* being the *Limits* of all Things whatsoever, *absolute Infinite* must be the greatest of all Things, and so can neither be encreas'd nor diminished, else it cou'd neither be the *Greatest*, nor the ascending *Limit*.

Corollary II.

Hence *absolute Infinite* is *One*, and *Individual*. Because being neither capable of encrease nor diminution, and being the ascending *Limit*, it must be *One*: And *Individual*, because there can be no other like it, it being the *One* ascending *Limit*.

Corol-

## Corollary III.

Hence *absolute Infinitude* is only compatible to the Divine Nature, and to nothing else. He being the greatest of all Beings, *One*, and *Individual*, or the single possible Being of the same Nature.

## Corollary IV.

*Universal Space*, is the Image and Representation in Nature, of the *Divine Infinitude*, for since by *Prop. 9.* the created *Species* of Things are Images of the Increated, and by *Prop. 10.* *universal Space* is the *greatest Limit* of the visible Creation, or material *System* of Things. Therefore *universal Space* is the natural Image of the greatest Limit of all Things, or of the *Universitas rerum omnium*. That is, by *Prop. 12.* and the *preceeding Corollary*, *universal Space* is the natural Image of the *Divine Infinitude*.

## Corollary V.

Hence *universal Space* may be very aptly called the *Sensorium Divinitatis*, since it is the Place wherein all natural Things, or the whole *System* of material and compounded Beings, are presented to the *Divine Om-*

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*niscience.* Infinite Space is the Image of the *Divine Infinitude*, wherein as in a Picture of Him (in whom all things Live and move and have their Being) all created Things present and manifest themselves to, the intuitive View of the *supreme Infinite*, and therefore in the *Analogy* of Things, Infinite Space is to the *supreme Infinite*, what a Humane *Sensorium* may be supposed to be to Men.

### Corollary VI.

An *absolute infinite Creature* is a Contradiction, because *absolute Infinite* is *One* and *Individual* by Corollary 2. of this.

### Scholium.

One very remarkable difference between *Finite*, *Relative* and *absolute Infinite* is this. *Finite* may still be increas'd by it self, and yet continues it's finite Nature, 'till the Number of Additions be actually Infinite. *Relative Infinite* may be increased, not by *Finite*, but by *it self*, and still continues it's Nature, after *Infinately-infinite* Additions, without Bounds or Limits: For let it be ever so often increas'd by it self, it continues but *relative Infinite*. But *absolute Infinite* can be increas'd by nothing, not even  
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by it self, else it cou'd not be the absolute or greatest Infinite. In natural Things *finite*, and *relative Infinite* never rise higher than the Third Power. The *Comets* and *Planets* move in *Orbits*, that are *Curves* of the *Second Power*. *Projectiles* move in *Parabolick Lines*, which are of the same Order. The *Curvature* of the *Surface* of all the *Celestial Bodies* are of the *conical-Section-kind*. The *Surfaces* of *Fluids*, rising in great or small *Channels*, are of the same rank. Nature admits but of *Three Dimensions*, and I know of no natural Effect, that rises higher than the *Third Power*. Even the *irrational Curves* that Nature forms, in conducting *solid Bodies*, and the *Rays of Light* (thro' different *refracting Mediums*) the shortest and easiest way: And in some other of her Operations, such as the *Cycloid*, *Conchoid*, *Catenaria*, *Velaria*, *Curva Elasticitatis*, *Logarithmica*, the *Spiral* and the like, all of them are of the lowest rank of their Order: And their Natures imply only Portions of *Curves*, or of their *Areas*, of the *Conical-Section-kind*, the lowest Order of all *Curves* whatsoever. So true it is that Nature perpetually brings about her Purposes *the shortest and simplest way*, and keeps constant to this beautiful *Analogy* of Things. But since Quantity may be still encreased,  $\infty$  may be supposed to rise to higher Powers than

$\infty^3$  in the intellectual *Species* of Things, such as are,  $\infty^4$ .  $\infty^5$ .  $\infty^\infty$ .  $\infty^\infty^\infty$  &c. Now tho' these Powers of  $\infty$  superior to  $\infty^3$ , can have no Place in natural Things, or the material *System*, yet are they the *intellectual Species* of created Things, and are in their respective Orders, *Images*, and Representations of their *Architypal Ideas*, in the Divine Mind, and Instances of the unexhaustible Store, of manifold Wisdom, in the Divine Nature. And as *infinite Extension* is the Image in Nature, of *absolute Infinite*, so  $\infty^\infty^\infty$  &c. is the Image of the same absolute Infinite, in the *intellectual Species* of Things. And by the *Analogy* of Things, relative Nothing, and relative Infinite are the *intellectual Images* of *absolute Nothing* and *absolute Infinite*, so universally does this *Analogy* hold good.

Proposition XIII.

*Absolute Infinite*, in the *Analogy* of Things, is the precise and proper Opposite to *absolute Nothing*.

*Demonstrat.* This is plain from Prop. 12. and it's first *Corollary*. For since a *Mathematical Point*, is the precise and proper Opposite to universal Space, and since in the *Analogy* of Things, a *Mathematical Point* is to *infinite Space*, as *absolute Nothing* is to *absolute*

*absolute Infinite*: Therefore *absolute Infinite* is the precise and proper Opposite to *absolute Nothing*. Besides, *absolute Nothing* and *absolute Infinite*, being the *Limits* of the *Universitas rerum omnium*, in Ascending or Descending from created Finite Beings. They must be precise and proper Opposites, having nothing common but their being *Entia and Limits*. q. e. d.

Corollary I.

Since *absolute Nothing*, in it's positive *Idea* implies the utmost impossibility of, and the most extreme Contradiction to *reality* or real Being, as it most certainly does, for it is not possible to conceive a greater Contradiction to, or impossibility of *Reality* or real Being, than is imply'd in the positive *Idea* of *absolute Nothing* or *Non-entity*, beyond which there is no further descending from *Reality* or Being. (It having no real *Entity*, tho' it may be class'd, as to it's negative Conception, in the *Category* of *Entia rationis*.) Therefore by the *Analogy of Things*, *absolute Infinite* must imply in it's positive *Idea*, and that necessarily, the utmost possibility, and the most extreme necessity of *Reality* or real Being.

Corol-

## Corollary II.

Wherefore since *absolute Nothing*, in it's positive *Idea* implies the utmost Contradiction to real Being, since *absolute Infinite*, is the precise Opposite to *absolute Nothing*, since also being Opposite in every thing (except as *Entia* and *Limits*, which do not effect the Realities in *absolute Infinitude*, as to it's positive *Idea*) *absolute Infinitude*, must imply in it's positive *Idea*, the utmost necessity of *Reality*, or real Being, therefore of necessity the *absolute Infinite* must really *Be*, or the Being to which *absolute Infinitude* is only compatible, must necessarily exist.

## Proposition XIV.

*Finitude* and *Infinitude*, when apply'd to natural and created Things, in their positive *Ideas*, imply not *Realities*, but the *Modes* of *Realities*.

*Demonstrat.* *Finitude*, when apply'd to natural or created Things, imports only in it's positive *Idea*, the Proportions of the several Degrees of *Affections*, or *Properties* of these Things to one another. *Infinitude*, the unboundedness of these Degrees of *Affections*, or *Properties*. *Finitude* and *Infinitude*,

*tude*, in themselves, abstracted from a proper Subject or *Substantive*, are incomplete *Ideas* in natural or created Things. *Infinite Extension, Number, Duration, Wisdom, Knowledge, &c.* are complete *Ideas*, whereof these *Realities* are the Subjects or *Substantives*, and the *Infinitude*, the *Epithet* or *Adjective*: Wherefore *Finitude* and *Infinitude* in natural or created Things, being but *Adjuncts* to *Realities*, in their positive *Ideas*, do not imply *Realities*, but the *Modes* of *Realities*. q. e. d.

Corollary I.

Hence the *Modes* of natural or created Things, are *Realities*, in the supreme or *absolute Infinite*, or the *Modes* of natural or created Things, when *Analogically* elevated to the supreme, and *absolute Infinite*, are in him not *Modes*, but the utmost *Realities*. This is plain from the *preceding Proposition*, and the *2d Corollary* of the 13. *Infinitude* is but a *Mode* in natural or created Things, but in the supreme or *absolute Infinite*, it implies in it's positive *Idea*, the utmost *Reality*, to wit, necessary *Existence*; and the same must of necessity be true, in all those *Attributes* of the *Divine Nature*, which *Analogically* deriv'd down to the *Creatures*, are in them but *Modes*, in  
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him they are the utmost *Realities*; because they are all complicated and affected with, or (so to speak) multiplied into *absolute Infinitude*, which *realises* those *Modes* of Creatures, and *Transubstantiates* them into positive and *real* Qualities. So true is the *Metaphysical Axiom*, *quicquid in Deo, ipse Deus est*. I do not here contend that there may not be *accessory Ideas*, in the Divine Intellect, or that there may not *Arbitrarily* arise in the Divine Intellect, *Images* of Beings, whose Existence is Fact, is not necessary. Since the *Idea* of a Creature, cannot be necessary to him, else they would necessarily be. But even those *Accessory* or *Arbitrary Ideas*, in the Divine Imagination, by being there, become of a quite different Nature from the like in Creatures, for by being there, they (by Virtue of his *absolute Infinitude*) receive a Being infinitely superior to the like *Ideas* in created Beings, not necessarily, but with infinite Freedom and Liberty. And those Affections and Properties in *Creatures*, which in them are but *Modes*, when *Analogically* carried up, to the like or similar Affections or Attributes in the Divine Nature, are in him the utmost *Realities*, as being complicated with *absolute Infinitude*, and thereby transform'd or exalted into real Quantities or actual Subsistences.

Corol-

## Corollary II.

Hence, *Power, Subsistence, Duration, Knowledge, Wisdom, Goodness, Beauty, &c.* which in created intelligent Beings, are the Images of *Omnipotence, Necessary Existence, Eternity, Omniscience, the Divine Sophia, Bignity, infinite Perfection, &c.* in the Divine Nature: And are but *Modes* of Being, and not essential affections in these, are in him infinite *Realities*, and living active Principles. And he that wou'd reason *Analogically*, from the Nature of these in created intelligent Beings, to the Nature of those in the Divine Essence, without having the utmost regard to the *absolute Infinitude*, which in a manner quite changes the Nature of the former, and exalts them into a different *Category*, wou'd be miserably mistaken. For Instance, he that, because the Duration of natural Things is *Successive*, wou'd conclude so of the Divine *Eternity*: He that wou'd reason because humane Power cannot give Being and Substance to that which had none, the Divine *Omnipotence* cou'd not: He that wou'd infer, that because the Knowledge of Rational created Beings is *Progressive*, the Divine *Omniscience* were also *Progressive*, must be egregiously mistaken: Because in this *Analogy*  
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he does not take in the *absolute Infinitude* which elevates and exalts the Duration Power and Knowledge of created Things, into a Degree of Reality of which these are but the Images or Pictures. He that from the Picture of a Man, wou'd *Analogically* reason about Humane Nature, from the blending and position of some Colours on Canvass, wou'd reason to Life, and Knowledge: Or from the reflected Image of the Sun in Water, wou'd conclude of Light, and Heat, cou'd not err more grossly.

### *Scholium.*

In intelligent compounded Beings: The *Powers* belonging to the Body, are not only Finite, but very low in the Order of Finites. The *Eye* perceives not distinctly a very large nor small Object. Too strong a Noise stuns the *Ear*, and one too weak does not act upon the *Organ*: Neither of them produces a distinct Hearing; and it is so in all the other Senses. Those *Organs* are so contriv'd, as to perceive best the ordinary Effects of common Life, the Objects that necessity of Subsistence do most readily present to us. These they are fitted for, and little else; they have a wonderful Facility in manifesting these distinctly to our Minds, and have a just Proportion to the Objects  
about

about us, but seem not contriv'd nor design'd for Curiosity, or conveying much more Knowledge to us, than what the conveniencies of Life require: Else infinite Wisdom and Power might have easily formed them so, as not to need those help and assistances, which we are obliged to employ when we aim at any more particular Knowledge of the intimate Natures of the Things about us, than conveniency makes necessary or commodious. The *Faculties* belonging to the Rational Soul are likewise Finite, but of a higher rank of Finities than those Powers belonging to the Body. The *Imagination* can paint a larger *Idea*, than the *Eyes* can see, and the *Memory* lodge a greater store of Images, than all the Senses can present at one time: And the *Understanding* can combine and disjoin these, and compare them many different ways: But still these *Faculties* are but Finite in their *Capacity*. We can form no distinct Ideas of *Millions* of *Millions*, of a *Multiangular Figure*, or any *relative Infinite*, small or great: The *Imagination* seems not able to contain these; there is no room on it, for so large Pictures. The *Memory* is the *Repository* of the Images that have been framed on *Phantasy*, and can go no further than it reaches; nay seldom or never contains more than a small part of those. The *Understanding* can work

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no further than these two afford Materials; it's Works being to *Collate*, *Combine*, and *Garble* as it were, these Images and *Ideas* the *Imagination* and *Memory* present to it. All these are Limited, as the Senses are, tho' not quite so straightly, because the *Understanding* may variously combine those *Idea's* they have convey'd to the *Imagination* and *Memory*, and so encrease their Number: And the *Will* having no subject Matter to proceed upon, but as it is prepared by these prior Faculties, can go no further than those allow it. The *Understanding* may diversify these as far as their *Combinations* will reach, and the *Will* may pick and choose among these, but since it cannot *create* Objects for it self to work on, it must be Limited to the Images and *Ideas* on the *Imagination* and in the *Memory*. The *Will* I mean, as it is Faculty belonging to the *Rational Soul*. All these Faculties seem to have been originally design'd for Nothing but this *material World*, and the System of Things about us. They help us to no Notion or Conception of any sort of Beings distinct from *Matter*, but in so far as *Analogy* will bear us out, and even as to the *material World*, they seem fitted for little else, besides the grosser, more general and more necessary Knowledge of Things that are required for due Conveniency, or Subsistence,

sistence, and show but some of the grosser *out-lines* of the real Natures of Things. Every thing that might violently entertain our Curiosity, or flatter our Vanity, as to the Knowledge of the Natures of Things: Seems to have been industriously conceal'd from us, and no Faculties to have been indulged us, for these purposes, least they shou'd have withdrawn us too strongly, from things of greater Moment to the end of our Being: Else infinite Wisdom and Power had contriv'd them after a more perfect Manner, with a larger *Capacity*, and a stronger *Energy*. As to the Faculties of the *supreme spirit*, (which is a third Part of intelligent compounded Beings) they most certainly are infinite in their *Capacity* and *Energy*, I mean they may be enlarged and encreased without Bounds or Limits, which by *Def. 4.* is to be relatively Infinite. Not only the *Acts* of these Faculties may be Multiplied perpetually, but the *Capacity* and *Energy* of these, may be dilated and intended without Bounds or Limits. The *Perception*, the *Desires*, the *Will*, (the Faculties belonging to the *supreme Spirit*,) are unlimited and boundless, fitted and design'd for *infinite Objects*. These indeed are the first, *Principal*, and *Original* Faculties, belonging to all compounded intelligent Beings: By which they are made capable of Communicating with the

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*supreme Infinite.* And next in order of Nature to the *supreme Spirit*, is the *Rational Soul*, whereby they are enabled to communicate with the *material World*: And to the Faculties of this *Secondary Part* of the Composition, the Senses of the Body are the *Conduits*, and Conveyances, which make up the Third and last part of compounded intelligent Beings: In the due *Subordination*, the perfect *Harmony*, and perpetual *Concord* of these Three, with each other, the *Perfection* of these Beings does consist: In their *Discord*, *Confusion*, and *Rebellion* one against the other, their *Degeneracy*, *Corruption*, and *Fall*. It can be no difficulty to those who are acquainted with the *Analogy* of Things, to conceive how these several parts of compounded intelligent Beings are contain'd without Confusion or Contrariety in each other; in their Primitive and uncorrupted State: When they consider, that in Water is contain'd Air, in that *Æther*, in that Light, and perhaps in this last, a more subtle and refin'd *Spirit*; and all these in perfect *Harmony*, and *Concord*. But to consider these a little more particularly. The *Perception*, as it belongs to the *supreme Spirit*, must of necessity be a *passive* Principle, because it cannot create it's Objects, but receive those presented to it: That it is Infinite, is plain, because it's adequate Object is Infinite, and the  
*supreme*

*supreme Infinite* : It being bestow'd on intelligent Beings, in order to Communicate with the *absolute Infinite*. The necessity of this Third Part of the Composition of the mention'd Rank of intelligent Beings shall be afterwards Demonstrated ; I proceed to consider in a few Words, the Nature of some others of these Faculties, belonging to the *supreme Spirit*.

Proposition XV.

The *Desire* is Infinite in it's *Capacity*, the most *Cardinal*, most *Quick*, and *Sensible*, and most *Active* Faculty of the *Mind* or spiritual part of compounded intelligent Beings, and the *Will*, and the *Affections* are but *Modifications* of it.

*Demonstrat.* To be convinced of the Truth of this *proposition*, we need only reflect on the Source of all the Happiness or Misery of intelligent Beings, and we shall find it arises from the enjoyment or disappointment of their *Desires*. There is in all intelligent Beings, a restless *Appetite* or *Desire* of Happiness : From the Moment of their Being, though all the Ages of Eternity, all their *Labour*, and *Travel*, is for this purpose : Nor are they devoid of it, either immediately in the *End*, or mediately in the *Means*, for one instant of time, in all their

endless *Duration*. Now this is the necessary Effect of the Faculty of *Desire*, no Object less than *Infinite* can satisfy it. For let it be supposed to have come to the Possession, of any Object less than *Infinite*, it's plain, it can *desire* yet a greater, and a greater, without Bounds or Limits; that is, it can desire an *infinitely great Object*, that is, the *Desire* it self, is infinite in it's *Capacity*; it's *Acts* are *Instantaneous*, and it's Enjoyments or Disappointments, for a time, swallow up the *Acts* of all the other Faculties: And therefore it is the most *Quick* and *Sensible*: It sets all the Powers of the whole Composition on Action, to obtain it's *Ends*, and therefore it is the most *Active*: And upon all these Accounts, the most *Cardinal* Faculty of the *Mind*: Choosing or refusing, that is *willing*, is but the *Desire* apply'd to a particular Object; the *Affections*, are but the *Complexions* of the *Desire*, as apply'd to this particular Object: And therefore are both but *Modifications* of the *Desires*, wherefore, &c. q. e. d.

*Scholium.*

To apprehend how infinitely Capacious, Active, and Sensible the *Desire* is, we need only imagine our selves, separated from the Objects of Sense, and the present *Amusement*  
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of *Life*, with all the Faculties of the Soul *awake*: And we shall then be able to conjecture, how *Strong, Active, Restless, and Unsatiab*le, our Desires wou'd be. So as to swallow up, and extinguish, all the other *Acts* of the Faculties of the whole compound. Those only can most sensibly feel the force of this reasoning, who have in some measure, and for some time been in this State.

Corollary I.

Since the *Desire* is *Infinite* in it's Capacity, and may be dilated beyond any finite Object, how great soever, it is evident it cannot be over-fill'd, or super-abundantly (so to speak) satisfied, with any Object less than *Infinite*: Since also, the greatest relative *Infinite*, cannot be assignable by *Corollary 1. Prop. 1.* Therefore the *Desire* cannot be adequately and over-fill'd with any less Object than the *absolute Infinite*; it being capable of being enlarged, beyond the Dimensions of any *relative* or *creaturely Infinite* assignable: And since by *Corollary 6. Prop. 12.* no *Creature* can be *absolutely Infinite*, therefore the *Desire* can be perfectly and adequately fill'd and super-abundantly satisfied, by nothing less than the *supreme and increated Infinite*.

## Corollary II.

Since the *Desire* is *Infinite*, when fill'd and satisfied with it's proper and *adequat Objects*, it must be infinitely Happy, for since nothing, by the *preceeding Corollary*, but the *absolute* and *increated Infinite*, can adequately fill, and super-abundantly satisfy it. The *absolute* and *increated Infinite* must be it's proper Object, and the *Desire*, *infinite* in it self, fill'd and perfectly satisfy'd with it's proper Object, the *supreme* and *increated Infinite*, must of necessity be infinitely Happy. Happiness arising from the *Congruity*, of the Object with the Faculty, and this *supreme* and *increated Infinite* being the proper and indeed the only proper Object, (since the *supreme Infinite* is *One*) it must alone be the *Congruous* Object, and so the Faculty being *Infinite*, the Object *Infinite*, and they infinitely *Congruous* to one another. The *Desire*, in the Possession or Enjoyment of this Object must of necessity be infinitely Happy.

## Proposition XVI.

In regard of *intelligent Beings*, every thing that is in the *Universitas rerum*, may be fully comprehended, under these Three  
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general Heads, to wit, the *Faculty* or *Desire*, the *Object* of this *Faculty* or *Desire*, and the *Sensation* arising from the *Congruity* or *Incongruity* between these two.

*Demonstrat.* All the distinct Subsistences that actually exist, are comprehended under these two general Heads, the *supreme* and *absolute Infinite*, and the *Creature*, and these can only be Objects of the *Faculty* or *Desire*. The *Faculty* or *Desire* being Infinite, by the *preceding Proposition*, may contain or receive both these, and the *Sensation* arising from their *Congruity* or *Incongruity* to the *Faculty*, must together with these two general Heads mention'd, comprehend every thing in the *Universitas rerum* in regard to any particular intelligent Being. For nothing can be Imagin'd in the whole extent of Being, *Real* or *Intellectual*, that may not be reduced to *Faculty*, *Object*, or *Sensation* arising from these. Therefore, &c. q. e. d.

*Proposition XVII.*

An *Intelligent Being*, compounded of a *Body*, *Soul*, and *Spirit*, with proper *Relations*, and in *Subordination* to each other, is a real *Epitome*, *Image*, or *Representation*, of the *Universitas rerum omnium*.

*Demonstrat.* This is so evident from the *Analogy* of Things; that there can be no

difficulty in it, to those who will consider, that the *supreme Infinite* cou'd have nothing more perfect than Himself and his other Works, and his own perfect Administration and Government of these; to form this compounded Being upon. He must be consistent with Himself, and his *compounded Works*, in their component parts, must resemble in the *lesser* Compositions, the *similar* parts of the *Greater*. This *intelligent compounded Being*, being to have a *material* part, what can it have more worthy of the Work of infinite Perfection, than his *greater System* of material Beings to resemble? His Soul or rational Part can resemble nothing more worthy of *Him*, than the other higher Orders of created Spirits: And his *supreme Spirit* or Mind, will bear it's best resemblance, when it represents the *supreme Infinite*. His Administration and Government of the whole *System* of created Beings, can be represented by nothing so aptly, as the Relations and Subordination of these to each other, and to the rest of intelligent Beings, which these cou'd only be formed upon. In a Word, it is impossible that any *Idea* of a compounded intelligent Being, made up of several parts, each *Similar* to some greater part of the *Universitas rerum*, already existent, cou'd enter to the divine Mind, which cou'd be  
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more perfect and more worthy of *Him*, than this, that each inferior part shou'd be an *Epitome* and Resemblance of his Works already made, and the highest part, of *Himself*, and that their Relations and Subordination, shou'd resemble his Administration of the whole. I say it is impossible it shou'd be otherwise, to preserve his Consistency with himself, and to carry on this *Analogy*, through every individual part of his Works, through the whole *Scale* of Beings, as it most certainly is carried, And this is not a meer *Metaphorical* Picture, and Resemblance, but the real and Physical Nature of compounded intelligent Beings. Wherefore, &c. q. e. d.

Corollary I.

From this Foundation, by a proper *Analogy*, with the due Limitations; all the *Relations* and *moral Duties*, of *intelligent compounded Beings*, to the *supreme Infinite*, to *similar intelligent Beings*, and to *themselves*, may be easily deduced; for Instance, do we resemble the *supreme Infinite*, in our *supreme Spirit*: Then as he is the first in *Order* of *Beings*, so is this part of our *Composition*, the first and most principal, in our *Order* of *Parts*. All the rest must be *Subservient* and *Subordinat* in us, to this, as  
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the rest of the several Ranks of Beings, are to him: This we are chiefly and mainly to Cultivate, by fitting it up for him, for whom it was *originally* design'd and bestow'd upon us. Here, we must aspire after *Him*, and open our *Desires* for *Him*, by a Love worthy of *Him*, superior Infinitely, to all our other *Loves* and *Desires*: On this part and it's Faculties, our Greatest, our Chief, nay, and our only Labour is to be bestow'd; that it may be Expanded, Dilated, and Elevated, to it's proper Rank in the *Order* of our Parts; that the due Subordination may be restored; which done, all the other Parts will perform their proper *Functions*, in *Harmony* and *Concord*. In regard to other *intelligent Beings*, we are to consider them, as like *Images* of *Him*, and *his Works*; and follow them with a *Benevolence*, proper to such *Images*, to imitate his Conduct of *Love* and *Forbearance*, to all his Creatures. But this only by the by.

Corollary II.

Hence, in a proper *Analogy*, the Nature of the *Spiritual*, and *Material* Parts of compounded intelligent Beings and of the *Union* between these, as far as they may be known by meer Humane Reason, is to be deduced. Compounded intelligent Beings, are *Epitomes*,  
or

or *Images* of the *Universitas rerum*. In their Bodies, they resemble the *material System* of Things, in their *Spiritual Parts*, they resemble the *Spiritual World*, the Union of these two is a resemblance of, (or is maintain'd and preserv'd after,) the Manner, the *supreme Being*, governs the *material System* of Things: Who being intimately present, with every individual *Atom* of Matter, yet more *eminently* acts from his superior *Throne of Glory*, having the whole *System* of Creatures, in one View presented to him, in the *universal Space*, his special *Sensorium*. By this Principle, as a *Key*, the whole *Phylosophy*, of Humane Nature, of the Animal, Rational, and Divine Life, of the Passions, and Affections of the Soul, and even of the *Organism* of the Body, so far as it is Just and Genuine, and given to meer Humane Reason to know, is to be unlockt, and that not *Metaphisically* but *Physically* and in Reality. But who is sufficient for the detail of these Things?

### Corollary III.

Hence, the *Immortality* of the spiritual Part, of intelligent compounded Beings, is evidently to be deduced. For since the *spiritual* Part, of intelligent compounded Beings, is an *Epitome*, and *Image* of the *spiritual*

*ritual World*; and the *supreme Spirit* (that part which God *originally Breath'd* into Man) is an *Epitome*, and *Representation* of the *absolute Infinite*; since by *Corollary 2. Prop. 13.* he *necessarily* exists, therefore the *Soul*, or *spiritual Part* (whereof this *supreme Spirit* is the *Fund* or *intimate Substance*) must exist for *ever*. Not necessarily, for that *Conclusion*, wou'd drop the proper *Limitation*, in the *Analogy*, arising from *absolute infinitude*: But, as being *Images* of him, who exists *necessarily*, and having their *Being* from him. Their *Immortality*, is indeed an *active, living Principle*, not of necessary, (but *deriv'd*) *Existence*. They are *Immortal*, as having represented on them, all his *communicable Perfections*; of which, *perpetual Existence* is one, tho' *necessary Existence* be not; that being contrary to *Creation*, or deriving a *Being* from another. *Immortality* in *Creatures*, is nothing but *perpetuity* of *Existence*, and if *Existence* at all be *communicable* to *Creatures*, *perpetual Existence* must be *communicable*: For *Existence*, being an *active, living Principle*, will of it self continue *Being* for ever, unless it be destroyed: Which is impossible, both from the *Immutability* of *God*, and the *Nature* of his own *Immortality*, of which this is an *Image*, or *Resemblance*. The *Immortality* of *spiritual Creatures*, is an *Emanation* from an *Image* of the  
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the divine communicable *Immortality*. And must resemble every thing in it, but *necessity*, that being a Contradiction to it's being *deriv'd*. But in every other Circumstance it perfectly resembles the *Immortality* of the superior Infinite, (as far as creaturely Properties can resemble Divine Attributes) and so cannot possibly be destroyed: And this is the true source of the *Immortality* of all Creatures. It is true, this *Demonstration* equally concludes the *Immortality* of all his other Works, since they are equally his *Images*, in a higher or lower Degree of Perfection: And without all doubt it must be so, for the *Gifts, and calling of God are without Repentance*. And this is the Genuine, and as the *Schools* call it, the *Apo-deictick Demonstration*, of the *Immortality* of all the Works of God, under some form or another, it is from their being his *Images* that their *Immortality* springs.

#### Corollary IV.

In the *Analogy of Things*, the *Desire* being the *Cardinal Faculty* of the Soul, and *Infinite* in it's *Capacity*, is as the *Infinite Space*, to the *Divine Plenitude*: Which infinite Space, nothing created, can adequately fill, but the divine *Plenitude*. And in this view, the *infinite Capacity* of the *Desire*, may be considered as a *Boundless Void*, made  
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to receive some *Fleeting*, limited Parts or *Systems* of Matter, acting by established Laws, and in comely Order, upon one another for a while, but can never be perfectly fill'd, or adequatly replenish'd, but by the *supreme Infinite*: Who is present with, and replenishes every point of the great and *universal Void* of Nature.

### Scholium I.

As in regard to intelligent Beings, the *Universitas rerum omnium*, is fully comprehended under these Three general Heads; the Faculty or *Desire*, the *Object*, and the *Sensation* arising from the *Congruity* or *Incongruity*, between these. So the same *Analogy* with proper Limitations, is preserved in the material *System* of Things. For answerable to these, we have in the *material World*, *Gravitation*, which wonderfully *Analogises* to the Faculty or *Desire*, in the *spiritual World*, and this to that; both being the *Active, Cardinal, and Energetick Principles*, of either *Systems* respectively. Next we have a *Mass*, of extended sensible Matter, if collectively considered, or *Systems* of *material Bodies*, diversly figured and situated in regard to one another, if separately considered: And in both these views, they admirably represent the Subject or Object of  
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the *Desire*, which is Analogised by *Attraction* or *Gravitation*. And lastly we have the *Harmonious, Comely, and Decent* Motions, and Actions of one Body upon another, arising from the *Attraction* or *Gravitation's* being impress'd on the *Mass*, and each particular Body; and this too, answers wonderfully to the *Third* Principle in the *Universitas rerum*. And this *Analogy* descends even to particular Bodies, for in these we have the *Form, the Subject Matter* and the *Congruity* between these.

*Scholium II.*

From the whole proceeding Chain of *intellectual Truths*, we may form to our selves some *faint, low, and imperfect Image* or Representation of the EVER-BLESSED TRINITY IN UNITY. For since, by *Corollary 1. Prop. 14.* the *Modes* of natural or created Things, when *Analogically* elevated to their similar Attributes in the *supreme Infinite*, in *Him*, are infinite *Realities*. Since, by the *same Proposition*, an intelligent Being is, as to it's spiritual Part, an *Emanation* from, an *Image* and *Representation* of, the *supreme Infinite*: And since also, in regard to these intelligent compounded Beings, all that is in the *Universitas rerum omnium*, may be fully comprehended under these Three general  
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Heads or Principles. The *Desire*, the *Object*<sup>s</sup> and the *Sensation* arising from the *Congruity* or *Incongruity* between the *Faculty* and the *Object*. Since lastly, this *Analogy* is preserv'd full and clear, through the *spiritual* and *material* Worlds, and each particular *Body*, that is, through the whole *System* of *Creatures*: It is highly probable, so constant, and universal an *Analogy*, can arise from nothing, but from it's *Pattern* and *Architype* in the *Divine Nature*: And without all peradventure, cou'd we fully and clearly carry it up to it's *Source*; we shou'd there find the *Origin* and *Source* of this **HOLY TERNARY**; or of these *Three* essential *Relations*, of the whole, to the whole in the completion of the **GODHEAD**. Let us therefore try, in some poor low manner, to carry up this *Analogy*, as high as possibly we can. The first thing then that we are to consider, in the *Divine Nature* is, the *Desire*, now this being supposed, to belong to a *supremely infinite intelligent Being*, must be an infinitely *Active*, *Ardent*, *Strong*, and *Powerful Thought*. And that, not as created, or *relative Infinitude* expresses it, but as the absolute and *supreme Infinitude* elevates this *Desire*. Now then this supremely *Infinite Desire*, this *Active* and *Ardent Thirst* after *Happiness*, or after a full, plenary, and compleat, *Beatifying Object*, we shall

shall suppose to represent the FATHER, the *Original* and first *Principle* in the Divine Nature: Seeing then, there is no consideration here of any thing but of *God himself*, nor is it possible for any other Object, but *God himself* to satisfy, and adequately to fill this *supremely infinite Ardor, Thirst, and Desire* of *Happiness*. Therefore *Himself*, reflected in upon *Himself*, viewing and contemplating his *own* infinite Perfections: The *infinite ardent Desire*, fill'd and satisfy'd with his own essential *Happiness*: The *brightness of his Glory*, and the *express Image*, (the essential *Idea*,) of his *Substance*, reflected in upon *himself*: Or *God himself*, *reduplicatively* contemplating *Himself* (He having nothing else possible, to be the Object of his *Love, Delight, or Desire*) represents to us the *Begotten Deity*, the SON, the second Divine *Principle* in the Order of the *Godhead*. Upon this *reflexion, contemplation*, and possession of *God-himself*, in *Himself*; there must of necessity arise, a *Joy, Happiness, Acquiescence, and Satisfaction* of *God-himself* within *Himself*, so much the more *Perfect, Full, Extreme* and *Infinite*, as his *Desire, Thirst, and Ardor* after *Happiness*, was *Active, and Strong*. And this may shadow out to us the third and last, in Order, of these essential *Principles*, in this *mysterious Ternary*, to wit, the HOLY

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GHOST. And tho' these three Relations, of the *Godhead* in it self, in regard to Creatures, and when deriv'd down *Analogically* to natural Things; may appear but *Modifications* of a real Subsistence, yet in regard to the *Divine Nature*, and considering his *supreme Infinitude*, they must be *essential*, and infinitely *real* and *living Principles*; and in this *Image*, and view of the **HOLY AND UNDIVIDED TRINITY**, *low* and *poor* as it is; It is impossible the SON shou'd be without the FATHER, or the FATHER without the SON, or both without the **HOLY GHOST**. It is impossible, the SON shou'd not *necessarily* and *eternally* be Begotten of the FATHER, or that the **HOLY GHOST** shou'd not *necessarily* and *eternally* proceed from both; *He* necessarily arising from the *Sensation* of the infinite Agreement and *Congruity* of the *Object* with the *Desire*. And tho' the *Idea Image*, or *Representation*, that *God* makes of *Himself* to *Himself*, be the same *God* in *Essence*, since it is a most perfect, express, and substantial *Image*, or *Representation* of the whole *Divine Substance* and *Nature*, and *necessarily* has in it, the whole, that is in *God*, and with the same infinite Perfections, that is really in the *Godhead*: Being only the *Divinity*, reflected in upon it *self*. Yet there is a difference, between the *Idea*, *Image*,  
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and Representation, and the original Divinity. For the same Perfections which are in the original and contemplating Divinity directly, are but indirectly, and by reflection in the contemplated and Begotten Deity; and they differ, by the Relations of Begetting, Contemplating, and Representing; and being Begotten, Contemplated, and Represented: And tho' these be only meer Relations, and Modifications, when transfer'd to natural and created things, yet are they infinite Realities in the Deity. It is the same with the Sensation, of Love, Joy, Acquiescence, and Happiness, that arises in the Divine Nature, from contemplating and possessing Himself and his own infinite Perfections, within Himself. And these three Relations, of Contemplating, being Contemplated, and of Acquiescence, arising from them: Which in a natural view, wou'd only be Modifications; Yet in the Divine Nature, are infinite Realities and essential and living Principles: And may serve as a faint and imperfect Image of THIS ADORABLE AND UNSEARCHABLE MYSTERY. Now tho' these views, and Representations, of this INEFFABLE AND INCOMPREHENSIBLE MYSTERY, arise naturally and necessarily from the Analogy of Things, sufficiently established in the preceding Propositions; and without all doubt, have some real Truth in them; since it is certain, these

Relations and Modifications of Subsistence, are really in *intelligent Beings*, in the *material System* of Things, and in *particular Bodies*: And cou'd have no other Rise and Source, but from their *Pattern* and *Architype* in the *Divine Nature*. Yet when apply'd to the *supreme Infinite*, these relations and distinctions, must be express'd in Words, that have a quite different Sense affix'd to them, by common use, from what they shou'd here *import*: And since the *Attributes* and *Relations* of the *supreme Infinite*, must be *Incomprehensible* to *finite Creatures*, especially to *Creatures*, conversant only about low, gross, and material *Images*; all I wou'd be understood to conclude, from this *Analogy*, thus rais'd to the *supreme Infinite* is, that *Reason* may form an *Analogical* imperfect *Image* (and that's all it can do) of this INCONCEIVABLE MYSTERY, which may in some measure help those, (who have not attain'd to a more perfect Guide or higher Lights) to believe the positive Relations of his own Nature, by *God himself*, tho' they be not able, perfectly to comprehend or express them. And if this poor Representation, of so PROFOUND A MYSTERY, so *Certainly*, and FULLY reveal'd in *Holy Writ*, can by the *Divine Blessing*, any wise Contribute, to *settle* and *quiet* sober and honest Minds, I shall have my full Intention.

Intention. Nothing less than *Omnipotence*, and *Omniscience*, being sufficient to deal with those, who are otherwise disposed.

*Proposition XVIII.*

There must of necessity be some *Principle of Action* in intelligent Beings, *Analogous* to that of *Attraction* in the material *System*, and that is, the *Principle of Reunion* with the *supreme Infinite*, by him originally impress'd on their *supreme Spirits*.

*Demonstrat.* That there must be some Principle of *Action* impress'd on intelligent Beings, *Analogous* to that of *Attraction* in the material *System*, is evident from the *Analogy of Things*, the *Consistency* of the Works of the *supreme Infinite* with themselves, the *Uniformity* conspicuous in all the *Creatures*, and that the material are but *Images* and *Representations* according to their respective *Natures*, of the *supreme Infinite*, as well as of the intelligent *System* of Beings. There must therefore some *great Principle* of *Uniformity*, run thro' both *Systems*, that is, the whole *Creation*. Now that *Attraction*, or something *Analogous* thereto, is the *great Principle of Activity* in the material *System*, has been sufficiently *Demonstrated* in the former Part of this *Treatise*. There must of necessity therefore, be some *great Princi-*

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*ple Analogous* to this, in the *System* of intelligent Beings. And that this can be nothing, but that great *Principle of Reunion*, with the Author of their Being, originally impress'd on every intelligent Creature: Is evident from hence, to wit, that the *supreme infinite Being*, infinitely powerful, and perfect, must necessarily subject, draw, and unite all intelligent Beings to Himself, to make them as happy, as their respective Natures can admit. That Himself is the *Sole Object* of their Happiness can not be doubted, there may be collateral and accessory Objects of their Happiness, but even these must flow from him: But that he is the supreme Object, and the single one that can adequately satisfy them, has been shewn before: That therefore, to bring them to this Happiness, he must impress upon, or derive to them, a *Principle of Reunion* with himself, is plain, because this is the single mean, to bring them to this end; for the known Law of Nature, obtains even here, and every where, to wit, that *Action and Reaction is Mutual*, so that if the *supreme Infinite* must draw them to him in Order to make them happy, they must have a Principle of being drawn towards him. That it must be a *radical and essential* Principle, is evident also, because this happiness is the very end of their Creation, it being  
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impossible infinite Perfection shou'd make intelligent Beings, for any less or any other *End*. Wherefore the *supreme Infinite*, cou'd not make intelligent Creatures, without *implanting* in their Natures, a *most ardent Desire*, an *essential Principle*, interwoven in the Substance of the spiritual Natures, of being re-united with Himself, in order to make them as happy, as their relative Natures will admit of. Besides, intelligent Beings (as to their spiritual part) are Images of the *supreme Infinite* by *Prop. 15*. In him there is an *infinite Desire*, and *Ardor* of possessing and enjoying Himself, and his own infinite Perfections, in order to render him happy, he himself is the *sole Object* of his own, and of the felicity of all his Creatures. There must therefore be an Image of this his infinite Desire after Happiness in all his intelligent Creatures; and this Image, can be nothing but this *Principle of Reunion*, since nothing but this can unite them with him, to make them happy. Lastly, an intelligent Being, coming out of the Hands of *infinite Perfection*, with an Aversion, or even Indifferency, to be re-united with it's *Author*, the Source of it's utmost Felicity, is such a shock, and deformity in the beautiful *Analogy of Things*, such a breach, and gape in the *harmonious Uniformity*, observable in all the Works of the Almighty,

and that too, in the noblest and highest part of his Works; as is not consistent with finite Wisdom and Perfection, much less with the *supremely infinite* Wisdom of the ALL-PERFECT. Wherefore, &c. q. e. d.

Corollary I.

Hence we may discover the Source, of *natural Conscience*, and of all those Motions and Convulsions, that are raised in the Breasts of compounded intelligent Beings, upon the *Commission* or *Omission* of certain Actions: Of that *Comfort*, *Joy*, and *Support*, in some; and of that *Dejection*, *Dread*, and *Terror* on the Minds of others; where no natural Causes can be assigned. Hence the *noble* and *sublime Discoveries* of the *antient Heathen Philosophers*, in the Principles of moral Virtues, without the assistance of Revelation. Hence it is, that *Scelerats*, can by no Arts, nor any Amusements how violent soever, stifle the Cries of a wounded Conscience; and hence also, it is, that honest and upright Minds, are sometimes swallow'd up, by a Tranquility and Peace that surpasses natural Understanding. That this *Principle of Reunion*, is defaced, buried, and in some measure as it were, obliterated, by contrary *Attractions*, by *Sensuality*, and the violent Amusements of Licentiousness in compounded

pounded intelligent Beings, is no more an Argument against it's *essentially* belonging to intelligent Beings, than the *Ideotism* of some is an Argument against the Principle of Reason in humane Nature. But

Corollary II.

From this *Principle's* being so *radically* implanted, in all the Individuals of intelligent Beings, and from the so very few Instances and Remains of it, conspicuous in the humane Race; we may gather the infinite and universal Degeneracy, and Corruption, of this set of intelligent Beings, from their *Primitive* and *Original* Institution. This Principle was most certainly implanted in their Creation, in the very *Fund*, and Substance of their Natures, and yet there remains but few Footsteps, and Instances of it's *Being*, or *Effects*. There are indeed (as in the Greater World) some *legible Characters*, *strong Out-lines*, and *prominent Lineaments*, of it's original Beauty, some *magnificent Ruines*, which show what it had been enough to Demonstrate the *original Impression*, Beauty, and real Being, of such a *Principle*, in all the Individuals of this Race, as is evident from the *Pangs* and *Tortures* of *natural Conscience*, when it is counter-acted. But the little effect it has, from

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from what it was design'd to have, is an evident Demonstration of the deep and universal Corruption of this *Set* of intelligent Beings.

### Corollary III.

Hence we may further discover, the Force, Truth, and Universality of this wonderful *Analogy of Things*, whatever we discover of the Works of Nature, is from this Source, and whenever we get the least *Glympse* into the manner of the Divine Operating, we discover fresh Instances of this *Analogy*. This *Principle of Reunion* in intelligent Beings, wonderfully *Analogises* with that of *Attraction* in the material World: As to the *supreme Infinite* it may be very properly called his *Attraction* of them, and as to them, their *Central Tendency* or *Gravitation* (so to speak) toward him; and this *Principle of Reunion*, if attended to, duly Cultivated, and Expanded, wou'd as certainly bring about, the Temporal and Eternal Happiness of all intelligent Beings, in the *spiritual World*; as that of *Attraction*, brings about the Comely and *Harmonious* Motions, of the *great Bodies* of the *material World*. This *Principle of Reunion* is the *original* Source and *Spring* of the *Desire*, afore Demonstrated, to be the  
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*Cardinal Faculty* of the spiritual Part of intelligent Beings. The *Principle of Reunion*, is the *Root* and *Foundation* of the *Desire*, in regard to it's first Cause and original Impression, by the *supreme Infinite*. This *Principle of Reunion*, as it is considered, as an infinitely *active*, *quick*, and *sensible Faculty*, in the spiritual part of compounded intelligent Beings, is the *Desire of Happiness*; as it is considered as a *Theological Virtue*, it is *Charity*; and as it is considered as a *Rule of Action*, it is *natural Conscience*. But the *Principle of Reunion*, in it's whole extent, as it was originally impress'd upon, and quite interwoven with the intimate *Fund*, and *Substance*, of the spiritual part of compounded intelligent Beings, is the *Source*, *Origin*, and *Root* of all these.

#### Corollary IV.

Hence, the true and genuine Nature, of *Moral Good* and *Evil*, and of all the *Moral Virtues*, and *Social Duties of Life*; as from their genuine Fountain and Source, is to be derived. Whatever retards, or opposes this *Reunion*, in intelligent Beings, is to them *Moral Evil*; whatever promotes, or advances this *Reunion*, is to them *Moral Good*. Besides, this *Principle of Reunion*, duly Cultivated, regularly Unfolded, and carefully

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carefully Attended to, must necessarily produce and perfect in the Soul *universal Charity*; that is, the Love of the supreme Being, and of all his Images in a due Subordination; and thereby instruct, and beget in the Soul, all the *Moral Virtues*, and *Social Duties of Life*. All these, being *virtually* and necessarily included in *Charity*. But to explain this matter (which is of the utmost consequence towards a right Apprehension of *solid Religion*) a little further, I say

### Proposition XIX.

*Charity*, or the Love of the *supreme Being*, and of all his *Images*, in a proper Subordination, according to their *Rank* in the *Scale* of Subsistences, is the necessary effect of this *Principle of Reunion*, when fully expanded, and set at freedom.

*Demonstrat.* By *Corollary 4. Prop. 17.* nothing but the *supreme* and *absolute Infinite*, can adequately fill and superabundantly satisfy, the *infinite Desires* of intelligent Beings, the *Desire* in intelligent Being is their *Love*, for no intelligent Being can desire any in order to make it Happy, but what it *loves*; or can *love* any thing, but what it *desires* to enjoy, (*Indifference* being the middle State, and *Aversion* the equal Opposite,

Opposite, both to *Love* and *Desire*.) So that an infinite *Desire* of the *supreme and absolute Infinite*, is an ardent *Love* of that *Being*. But the *Principle of Reunion*, expanded, set at freedom, and arriv'd at it's *ultimate End and Center*, is intirely the same with the *infinite Desire* in intelligent Creatures, possess'd of it's sole and proper Object, the *supreme and absolute Infinite*. Consequently the *Principle of Reunion*, expanded, and set at freedom, in order to arrive at this *ultimate End and Center*, must necessarily beget, in the Spirits of intelligent Creatures, this *infinite Desire* of the sole and proper Object; that is, an *infinite Love* of the *supreme Being*: And by necessary consequence, a *Love* of all his *Images* in proportion to their *resemblance* of Him; that is, the *Principle of Reunion* when expanded, and set at freedom, must necessarily beget, in the Spirits of intelligent Beings, a *Love* of the *supreme Being*, and of all his *Images* in a proper Subordination, according to their *Rank* in the *Scale* of Subsistences, that is *Charity*. q. e. d.

#### Corollary I.

Hence, *Charity*, or the *Love* of the *supreme Being*, and of all his *Images* in a proper Subordination, in it's true and genuine

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nuine Nature, is not founded on *Interest*, or the *views* of Rewards and Punishments; but altogether, on the *abstracted Perfections* of it's Object, the *supreme Infinite*. *Charity* in it's Origin, and as it ought to be, according to the true *Analogy* of Things, is a *Physical*, and necessary consequence of the *Principle of Reunion*: It flows naturally from an *implanted Faculty*, and has for it's Object the *supreme Infinite*, in his own *independent* and *essential* Nature, as he is *absolutely Good*, and *Perfect*, without any *collateral Views* or *Regards*. *Charity* is in a higher degree, and in a more noble Creature (one, to wit, endowed with freedom and liberty of Acting,) what *Motion* proceeding from the *Principle of Gravitation*, is in *Brute-matter*, or what the *Tendency* of the *Planets* is, towards the *Sun*, viz. a natural Consequence, of an implanted Principle. This is so clear and so certain, in true *Phylosophy*, that it is matter of *Astonishment* to me, how it came once to be doubted, much less disputed. *Henry Moor's* Argument on this Head, is as cogent and just, as any Demonstration in *Euclid* or *Apollonius*. “ *As the Object of the Intellect* “ *(says he) is that which is simply true,* “ *and is assented to as such, and not as true* “ *to this particular Intellect which contem-* “ *plates it, so there is an Object that is* “ *simply*

“*simply Good and Lovely, and to be Loved as such, without regard to the Party that thus loves it.* And in another place, he uses the familiar Illustration of *Ginger-Bread* and *Mathematicks*, wherein he grants the former, may be a Spur to the latter, ’till Age and good Sense, with the Knowledge of the intrinsic Beauty and Worth of the latter, makes the *Student* in Love with the *Study* it self, without any consideration of the *Childish Bait*. As in natural Love, Persons become often enamoured of *outward Beauty*, without any particular Knowledge of it’s Possessor, or it’s *attainableness* by them; so without all peradventure, *infinite Perfection* for it’s own intrinsic *Pulchritude*, must be the proper Object of *Divine Charity*, without any particular regard to the Party loving it. Not that *Interest*, or a *View to Rewards* and *Punishments*, is not often the only Motive of *Divine Love*: And always is a very proper and *laudable* one, when *infinite Perfection* is the Object. And in reality, it is as high, as most of the *lapsed Race of Adam*, in their degenerate State can rise to. But as things are in their *original Natures*, were in their *Integral*, and must be in their *reintegrated* State. *Infinite Beauty*, or *Perfection*, without any regard to *Self-interest*, or any view to *Rewards* or *Punishments*, is, was, and must

must be, the proper and sole Object of pure and perfect *Divine Love*, or *Charity*.

Corollary II.

Hence the *Service*, *Worship*, and *Homage*, we owe to the *supreme Being*, is founded intirely upon his own *original Excellencies*, and *Perfections*, and not on his *Rewards* and *Punishments*; there neither ever was, nor ever cou'd be, any room for *Contracts*, or *Pactions*, between the *supreme Being*, and his intelligent *Creatures*, in the original *Constitution* of Things. *He made all Things by the Word of his Power*, and for his *Pleasure they are and were created*. *Infinite Perfection* is to be *Lov'd*, *Admir'd*, *Ador'd*, and *Serv'd*, for being infinitely perfect *Antecedently*, and without any regard to *Creatures*: And when *Creatures* are brought into *Existence*, this *primary Reason of Love*, and *Adoration*, subsists, and in order of *Nature* and *Dignity*, is *prior* and *preferable* to all other *Reasons*. *Creation* adds nothing essential to *infinite Perfection*, but a *Circumstance* only, which too, intirely *evanishes* when brought into *Comparison*, with the original *Beauty* of the *absolute Infinite*. All his *Creatures* that act naturally, correspond, and are faithful, to the greatest exactness, to his *original Impressions*, and his appointed



brought about, makes Himself and his own Happiness, his *ultimate End*, and so places himself in the Rank and Order, that belongs to GOD only, and himself becomes his own *Idol*. He only can be said truly to *Love* GOD, with a *Love* undivided, and worthy of him, who having *loved him*, as far as *Rewards and Punishments* will carry him, goes on still further to *love him*, looses all views of these *mercenary Motives*, and seeks for no Fuel to feed the *celestial Flame*, but the *unexhaustible Pulchritude*, and Perfections of the *beloved Object*.

Proposition XX.

*Charity*, or the pure and disinterested *Love* of GOD and of all his *Images* in a proper Subordination is the *end of the Law*, the *Accomplishment* of all the *Graces*, and the consummate Perfection of *Christianity*.

*Demonstrat.* On these Two, to wit, the *Love* of GOD and our *Neighbour* hang both the *Law* and the *Prophets*, says the **ADORABLE AUTHOR OF CHRISTIANITY**, and the *Apostle* says, *the end of the Law is Charity*, if the *supreme Being* is the *ultimate Object* of the *Felicity* of all intelligent Creatures, and *Charity* the mean to attain this end, as is evident from the *preceding Proposition*, then is *Charity* the consummate *Perfection of Christianity*. The  
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whole of *Christianity* is nothing but Rules for attaining this *Love*, or Measures whereby to remove the Impediments that hinder this *Principle of Reunion* (the source of *Charity*) from Operating, or means to destroy the contrary *Attractions* which disturb the natural Operation of this *Principle of Reunion*; which wou'd of it self, if not Stifled, Opposed, and Counteracted, necessarily beget this *Divine Charity*, whereby the Soul wou'd instantly be united with it's *Center*, and *ultimate End* the *supreme and absolute Infinite*. q. e. d.

*Scholium.*

To this Doctrine of *pure Love*, there are made but Two Objections which have any Weight or Force in them. The First is, that the *Motives* for *Love and Obedience*, urged by *Moses* and the *Prophets*, CHRIST and his *Apostles*, are founded on *Rewards and Punishments*, and that therefore without *Blasphemy*, we are not to offer at, or pretend to, more high and sublime *Motives* or Principles, than the *Friend of GOD*, and the *SON OF GOD*, (the Standard in their several Dispensations, of Purity and Perfection) thought fit to press or propose. The plain and genuine Answer to this Objection is, that the *Author of our Being*, who loves all his *Creatures better*

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than they can love themselves, uses all Motives that are *Honest, Laudable, and Just*, to gain them; he knows perfectly the *Frame and original Complexion* of all his Creatures, and that in their *lapsed State* they must ascend to Perfection by Steps and Degrees; and consequently that some are to be wrought upon by one *Motive*, others by another, and that generally the first Steps are mounted by the force of the *Terrors of the Lord*, before the *Love of GOD* is shed in their *Hearts*. There are *Babes in CHRIST*, as well as *grown and perfect Men*, and their *Food* (or Motives to Charity) must be as their *Years and Strength* are: But our *SAVIOUR* tells us, we must love the *LORD our GOD* with all our *Heart*, with all our *Soul*, with all our *Strength*, and with all our *Mind*, and if so, we shall have very little *Love* left behind, for our *selves*. And his beloved *Disciple* tells us, that *perfect Love* casteth out *Fear*, and consequently *Hope*, that is, *Rewards and Punishments*: Which are true, good, and *salutary* Motives, tho' not the best. The second *Objection* is from the impossibility of *Loving* or begetting *Love* without a  *REGARD* to *Rewards or Punishments*. But this *Objection*, arises from *Ignorance* of the true *Nature* of this *Affection* of the *Soul*. *Love* is the *Complexion* of the *Will or Desires*, as was shown *Prop. 15*. it belongs to the  
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*uninlighten'd Faculty* of the Mind, the *Will*, and not to the enlighten'd Faculty, as the *Understanding* is, and so naturally, and of it self has no real respect to *Rewards* or *Punishments*, which are Motives offer'd by the *Understanding*; we *Love* because we will *Love*, without *Reasoning*, or because the Object of our *Love* is amiable, and not because it will hurt or heal us. *Love* is Blind, and belongs intirely to the *Will*, and not to the *Intellect*. But passing this, as perhaps too *Metaphysical*, I answer, *Secondly*, as we may for one single *Instant*, and for one single *Act*, abstract from a Reward, forget it, or counteract it, (which no Body who knows the prescindent Faculties of the Soul, and that *Love* and Rewards are essentially united in their own Natures, can deny) so we may thus *Abstract* again, and again, and so in *Infinitum* and thus beget a *Habit* for what may once be done, may for any impossibility in the Nature of the thing, be done for ever: This is *Demonstration*. But I proceed,

*Proposition XXI.*

In all intelligent Beings, there must be *Faculties* fitted for all the several *Ranks* of Objects, in the *Universitas rerum*; that is, since there are evidently Three *Ranks* of

Objects, in the *Universitas rerum*; to wit, the *material System* of Things, the *spiritual World* of created Spirits, and the *supreme and absolute Infinite*. Intelligent Beings must necessarily be fitted, with *Faculties* suited to these Three generical Ranks of Objects.

*Demonstrat.* This is evident from the several different *Mediums*, which all infer the same Conclusion. 1. Intelligent Beings are *Images* of the *supreme Infinite*, who alone perfectly comprehends and knows himself and all his Creatures, that is, all these Three generical *Objects*, in the *Universitas rerum*. He has different Sensations and Perceptions (as far as *Diversity* can be consistent with his infinite *Simplicity*) arising in himself from all these Three different *Objects*, and consequently *Faculties* fitted for them: Therefore intelligent Creatures, his *Images* the *Representations* of all his communicable Perfections, must of necessity, have *Analogous* *Faculties*, fitted for all these Three different *Objects*. 2. There are *Relations*, incumbent upon all intelligent Beings, towards each other, and towards the *supreme Infinite*. Such as *Love*, and *Benevolence*, therefore intelligent Beings must be endow'd with *Faculties* fitted for receiving the Impressions, and to perceive the effects of these *Relations*, else they wou'd be in vain: And these are Two of the different Ranks of  
Objects;

Objects; and no body questions intelligent Beings, being fitted with Faculties for the Third; to wit, the *material System* of Things. 3. As to the *spiritual World*, including the *supreme* and *absolute Infinite*, as it's *Head*. The *Principle of Reunion*, whose necessity in intelligent Beings, I have now Demonstrated, makes it absolutely necessary, they shou'd be provided with *Faculties* fit for *Communication* and *Union* with the *supreme Infinite*; else, they were not susceptible of that Happiness which was the *sole End* of their Being. 4. That which is the *Apodeictick Demonstration*, of the Truth of this *Proposition*, and at the same time proves the Diversity of these several Faculties, to be as real as that of the Objects is, is the manner after which compounded intelligent Beings, are provided with *Faculties* for the *material System* of Things. Material Things are presented to them only through their Senses; they have a real and material *influx* on these; else they are not really perceiv'd; and all real Knowledge of material Things, is convey'd into the Understanding, through these *Senses*. Wherefore it is evident, compounded intelligent Beings, are endowed with a Faculty of perceiving or receiving material Things, thro' their Senses, which is called *perception*. Next they have a Faculty of painting these Perceptions or

their Images when the Objects are absent, and this is called Imagination, and *lastly*, a Faculty of *Combining* and comparing the real Perceptions of these material Things or their *Images*, and this Faculty is called *Reason*. And all these *Three* distinct Operations belong to the *rational Soul*, in order to fit it for Communication with the material World. Now by the *Analogy* of Things, such like, and *similar* Faculties, must of necessity belong to the *spiritual* part of compounded intelligent Beings, to fit them for a communication with the Two remaining *Ranks* of Objects; to wit, a *spiritual Perception* and *spiritual Senses*, *Imagination* and *Understanding*, for the *spiritual* World of intelligent Beings, and *Divine Senses*, *Perception*, *Imagination* and *Understanding*, for communicating with the *supreme Infinite*. For this *Analogy* will perpetually hold good and true, from the *Simplicity* and *Unity* of the *Divine Nature*, to wit, such as the Faculties are by which we *communicate* with the *material* World, such *Analogically* and with proper Limitations, are those by which we *Communicate* with the *World* of Spirits, and the *supreme Infinite*. And as we see compounded intelligent Beings, have bodily *Senses* which solely belong to the *material* World, so in the *Analogy* of Things, they must have Faculties different  
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different and distinct in themselves peculiarly fitted and appropriated to the other Objects in the *Universitas rerum*. Wherefore, &c. q. e. d.

*Corollary I.*

Hence, we may conceive the Reason why in *Holy Writ*, the whole Man is distinguished into *Body, Soul, and Spirit*; whence comes the distinction, of the *natural*, and *spiritual* or *inward Man*: Between the *Law of the Members*, and the *Law of the Mind*. These Distinctions, and Divisions, I say, are easily conceiv'd from the foregoing Proposition. For the Body and rational Soul belong to this *material System* of Things, and are fitted with Faculties for *Communicating* with it, and is called the outward Man, and the following it's practical Dictates in Rebellion against, and in Opposition to, the Dictates of the *Spirit*, the *inward Man*, the essential *Principle of Reunion*, the *Law of the Mind*, which is fitted only for *Communicating* with the *supreme Infinite*: I say, the following the practical Dictates of the first, in opposition to the *Dictates* of the latter, is called in the Language of the *Spirit*, the following the *Law of the Members*.

*Corol-*

Corollary II.

As there are *Three* different Principles, Orders, or *Predicaments* of Being; to wit, GOD the *Creator of all Things*, created *Spirits*, and *material Bodies*: So there are *Analogically* in compounded intelligent Beings, *Three* different and distinct Principles, adapted and appropriated, for Communicating with, and enjoying these respective Objects: Whereof every one is endowed with proper *Senses*, *Powers*, and *Faculties*, different and distinct from each other. That is, as the *material System* of Things, is the proper Object of the Senses, and rational Soul; and as this Principle is fitted with outward *Senses*, *Perception*, *Imagination*, *Understanding*, and *Will*; So the Principle, whereby they are fitted, to Communicate with the created spiritual World, is endowed with inward *Senses*, *Imagination*, *Understanding*, and *Will*; and the *supreme Spirit*, or Third Principle, whereby they are fitted to Communicate with the supreme uncreated Infinite, is endowed with *inmost* (so to speak) *Senses*, *Imagination*, *Understanding*, and *Will*; and all these in their *primitive* and *original* Constitution, in Subordination, *Harmony*, and Agreement, without Contrariety or Confusion one with another.

another. This *Corollary* is as certain as the *Analogy* of Things is.

*Corollary* III.

Hence, we may deduce the true and genuine Nature, and Extent, of the *Degeneracy*, *Corruption*, and *Fall*, of the Humane Race of intelligent Creatures; which consists, in the *Confusion*, *Discord*, *Rebellion*, and *Contrariety*, of these different and distinct Principles one with, and against another; in throwing of that *due Subordination*, *Subjection*, and proper *Rank*, and *Order*, that was originally established among these Faculties; according to the Dignity of these different Objects; the Order of Nature, and the *Analogy* of Things, and following the practical *Dictates*, and Conclusions deduced from these rebellious Faculties. That is, when in this *Anarchical* and rebellious State, of humane Nature. The Faculties belonging to the material World, presumes to Judge of, and determine the Nature of the Subjects, belonging to the *supreme* Spirit; takes the Government and Administration of the whole Man, which properly belongs, in the Order of Nature, to this Third Principle, leads the other Principles, as *Slaves* and *Captives*, and forces them to comply with the practical *Dictates* they prescribe,

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and deduce in their usurp'd Superiority; and under this compliance, begetting and producing physical and durable Effects, the whole Order of Nature, and the material *System* of Things, so far as these *physical* and durable Effects reach, becomes Distorted, Inverted, and Corrupted.

*Proposition XXII.*

The *rational Soul*, is not that Faculty in compounded intelligent Beings, which in the Order of Nature, and the *Analogy* of Things, is appropriated for the spiritual World (including the supreme Infinite as it's Head.)

*Demonstrat.* Tho' this be a necessary *Corollary* from the preceding *Proposition*, yet since it is of great consequence to true Divine Knowledge, to have it's Truth established beyond all possibility of *Cavil*. I shall here suggest some other *Mediums*, or set those already suggested in another Limit, from whence the same *Conclusion* may be deduced. And 1. this is evident from the Nature of this *Faculty*, and the manner of it's Operating. *Reasoning* is the comparing, or the considering the *Congruity* or *Incongruity* of the Perceptions, suggested by the Senses, or of the *Ideas* lodged in the Memory, or Painted on the Imagination, to one another; and *Reason* is the Faculty whereby

whereby this is perform'd. Now the *Senses* send in only, the *Influxes* of material Things, and the *Imagination* and *Memory* present only their Pictures or *Images*, when the Objects themselves are absent; and here is all the *rational Soul* can do. But nothing of these belong to the *supreme* and *increated Infinite*, nor the *spiritual World*.

2. It is acknowledged by all, and every one's Experience demonstrates it to Him, that the *rational Soul* is fitted for *Communicating* with the *material World*. Now since *Body* and *Spirit* are precise and proper *Opposites*, it wou'd be as *Dissonant* and *Incongruous*, in the *Analogy* of Things, that the same Faculty shou'd be the Principle of Communication with these two Objects, so widely distant, as that the *Eye* shou'd both *Hear* and *See*. It is true it may be said, that the *rational Soul* might have been originally endowed with such *Energy* and *Capacity*, as to be fitted for *Communicating* with *both Worlds*; but this is meerly *gratis Dictum*, and perfectly contrary to the *Analogy* of Things. It being impossible, to bring an Instance of Nature, where things so widely distant, and precisely opposite are receiv'd by *one and the same* Faculty; we see in the *Body*, or lowest part of the humane Composition that it is instructed, with *Organs* fitted for all the possible ways, ma-  
terial

terial Things can act upon it. And they are not near so widely distant and different in their manner of Operating, as Bodies and Spirits in their Natures are. 3. There is a Two-fold Knowledge of material Things, one *Real*, when the thing it self, and the *real* Action and Impression thereof, on our Senses is perceiv'd. The other *Ideal*, when the *Image* or *Idea* of a thing absent in it self, is represented to, and considered on the *Imagination*. For Instance, the *Heat, Light,* and *cheerful Influences*, of the *Sun*, shining on us, are widely different, from the view and consideration of it's *Image*, or *Idea*, on our Fancy. In the *Analogy* of Things, and according to the constant Order of *Nature*, such must our Knowledge of *spiritual* Objects be, to wit, the one *real*, when the Objects make a real Impression upon the *appropriated* Faculty; the other *Ideal*, when we frame a Notion, of it's absent Substance and Qualities. Now it is very plain, the *rational Soul*, is not fitted for this first kind of Knowledge or Perception, of *spiritual* Objects; since a great many *Philosophical* and *Learned Men*, who have exercised this Faculty in it's greatest Strength and *Vigor*, have deny'd the Existence of such Objects. 4. Lastly, That most certain and self evident *Metaphysical Axiom*, to wit, *that nothing can be in the Understanding, that*  
was

was not first in the Senses; is a certain Demonstration, that the *rational Soul*, is not the Faculty in intelligent Beings, appropriated to the *spiritual World*; for every Body allows, that *spiritual Beings*, as such, can never be convey'd, through the bodily Senses, to the Understanding. And therefore we must either be intirely depriv'd of Faculties, for communicating with *spiritual Beings*, (that is we must be depriv'd, of the only means of our *supreme Felicity*, and for attaining the end, for which alone we were created, to wit, communicating with the *supreme and absolute infinite Spirit*.) Or else, we must be endow'd with Faculties distinct from the *rational Soul*, for that purpose. Upon all which Accounts it is evident beyond the most remote possibility of Doubt, that the *rational Soul* is not that Faculty in compounded intelligent Beings, which in the Order of Nature, and the *Analogy of Things*, is appropriated for the *spiritual World*: But that they are endow'd with a *rational Soul*, and bodily Sense, to communicate with the *material World*, and with a *Spirit and Divine Senses*, to communicate with the *supreme Infinite*. So that the mentioned *Metaphysical Axiom*, continues just and true, as it shou'd according to the *Analogy of Things*: That as *material things*, are convey'd to the *rational Soul*, through the *bodily Senses*, so  
*spiritual*

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## 112 Philosophical Principles

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*Spiritual Things* (those that relate to *supreme Infinite*) are convey'd through the *Divine Senses*, to the *Spirit*. q. e. d.

### Corollary I.

Hence, in the *Analogy of Things*, as the *Light of the Sun* (that *Noble and Glorious Representation, Image, and Vicegerent* of the *supreme Infinite*, in the *material World*) is the *Medium*, through which *material Things* are seen and perceiv'd in our *System*, so the *essential Light* of the *supreme Infinite* himself, is the sole *Medium*, by and through which, his *Nature* and *infinite Perfections* are to be understood, and comprehended. And therefore as certainly, as the *Sun* sends forth his *Light* on the whole *material World* without *Bounds* or *Limits*, on *the Just* and on *the Unjust*; so certainly, the *Sun of Righteousness*, the *Pattern* and *Archetype* of our *material Sun*, sends forth his *enlightning* and *enlivening Beams* on all the *System* of created *intelligent Beings*, and is, *that Light which enlightens every Man that cometh into the World*.

### Corollary II.

Hence it is evident, that he who wou'd *Judge, Determine, and Pursue* the *practical*  
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Conclusions of these Determinations, about the Nature and Properties of *Spiritual* and *Divine Things*, by his *Reason*, wou'd act as incongruously, and contrary to the *Analogy of Nature*, as he who wou'd taste Colours (as such) and look into Sounds. The highest that this *Faculty* can justly and congruously pretend to in these Matters, is from the known, certain, and experienced Nature, and Properties of *material Things*, (to which the *rational Faculty* is in some measure adequate) by a proper *Analogy*: And from the *Visible's* being low *Images* of the *Invisible*, and *Spiritual*; to frame *Similar*, but imperfect *Likenesses*, and Representations, of these superior Objects; their Natures, and Properties, as we have endeavoured to do, in the preceding *Propositions*, and this really, and in fact is all that *Reason* can do in these sublime Matters.

### Corollary III.

Hence, we may discover the Errors and Impieties of *Spinoza*, and *Hobbes*; and the Mistakes of a latter *Philosopher*, I mean (the otherwise *Ingenious*) Mr. *Lock*. The first of these, considered this *universal System of Things*, as a kind of a *Huge-brute-animal*, actuated by a fatal, necessary, unintelligent, undesigning Principle;

dom or Choice. The *Second*, considered *humane Nature* (not as it really is in it's present state of *Probation* and *Purification* a Mixture of moral and natural Good and Evil, but) in it's *Diabolical* and *reprobated* Estate: Not as Groaning under it's present State of Corruption, and waiting and panting for the glorious *Liberty of the Sons and Children of God*; but as it will be in an habitual confirm'd Estate, of the *Anarchy* and *Rebellion* of it's *Faculties* one against another. In a Word, he considered *humane Nature* only, as it is in the worst of Men; or as it is supposed to be at last in a State of *final Impenitence*, and harden'd *Impiety*; and this he took as his *Original* to copy after, and his *Model*, whereupon he was to frame his *humane Creature*: And it must be allowed he has wrought it up to *the Life*. The *Third* considered *Man*, and his *Faculties*, not indeed in their already *reprobated* and *Hellish* Estate, but as he really now is, in the World, a composition of moral and natural Good and Evil: And this State he has very fairly and justly represented so far as it goes. But then, either having no Notion, or at least no Regard, to his *higher Faculties* (which in natural and lapsed Man, ly Buried under the Rubbish of his present Corruptions and Sensuality;) nor to his *regenerated, re-integrated* and *re-established* Estate, (to which he

he must be restored before he can reach the *End* of his *Being*.) No not so much as to consider Man, as he really is, a *fall'n*, *depraved*, *vitiating* Creature, (in which State his *lower*, his *rational* Faculties are impaired; his *higher* Faculties, in some measure *obliterated*, at least Buried and Oppressed by the load of present Corruption and Sensuality: And all of them in a State of *Anarchy*, *Rebellion*, and *Contrariety* one to another.) I say, from having no regard to those *other* different, *real* Estates of *humane Nature*, his Accounts of it's Faculties, are *Lame* and *Imperfect*. His *Principles* when apply'd (by himself or his Disciples) to Subjects (to which Faculties are appropriated, higher than those he *elicits* out of the meer lapsed State of humane Nature) of a more elevated Order (such as *Christianity* and it's *Holy Mysteries*, *Faith*, *Grace*, *Divine Revelation*, and *Inspiration*, and the Means of Man's Recovery) debase these into *meer Heathenish Morals*, or *Humane Philosophy*, and sink the *Oeconomy* of the *whole Wisdom* of the *Godhead*, even below the poor Contrivances and barren Speculations of many of the *Gentile Sophists*. But those who fully understand the *Principles*, and are convinced of the *Truth* of the *Propositions*, I have laid down, will easily perceive the ground of the Errors and Mistakes of these Three

*Setts of Philosophers*: And be able to answer their Arguments without my being obliged to detail them.

Proposition XXIII.

In the *Analogy of Things*, and Order of Nature, as the *material World*, is to *Universal Space*, it's highest Limit and Boundary, so is the *Spiritual World* to the *supreme and absolute Infinite*, the highest Limit and Boundary of all Things.

*Demonstrat.* This is evident from *Lemma 1*, with *Prop. 9.* and *17.* There is a Beautiful *Analogy*, and Uniformity running thro' the whole *System of Creatures*. The *Visible* and the *Created*, are *Images* of the *Invisible* and of the *Increated*. The *System* of intelligent Beings are more exalted, more noble, and more immediate *Images* of the *supreme Infinite*. The *Analogy of Things* runs quite through the whole *System of Creatures*, up to their original Pattern and *Archetype* in the Divine Nature, in a continued Subordination and Scale; according to their respective Natures. The *material World* is an *Image* of the *spiritual World*, as the *spiritual World* is of the *supreme Infinite*. As *Infinite Space* is the *Locus* and Boundary of the *material World*, so is the *supreme Infinite*, the *Analogical Locus* (in whom

whom *they all Live, Move, and have their Being*) and the *Omega* of all Things, *Spiritual* and *Material*. And as *Space* is *Similar* to a *spiritual Substance*, so is that to the *Divine Substance*, therefore, &c. q. e. d.

Corollary I.

Hence *material* and *spiritual Substances*, are both of them *extended*; for since the *material World*, is to *universal Space*, as the *spiritual World*, is to the *supreme Infinite*; and since both *Matter* and *Space* are extended, so also must *spiritual Substances* be: And the *Divine Ubiquity*, and *Omnipresence*, not *Virtually* only, but *Substantially* and *Essentially*; makes it not unlikely that there may be, in the *Divine Substance*, a resemblance of *Extension* (so far as a resemblance and similitude of Substances can reach; between a *relative Infinite*, such as *universal Space* is, and the *supreme Infinite*) but infinitely more pure and perfect, than that of created *Space* is, or can be.

Corollary II.

Hence *Matter* and *Spirit* are *Opposites* in every other *Quality*, except in that of *Extension*; for since by *Conversion of Ratio's*, the *material World*, is to the *spiritual World*, as

*Infinite Space* is to the *supreme Infinite*; and and since these two last, to wit, *universal Space*, and the *supreme Infinite*, are opposites in every other Quality, but in a resemblance of Substances, and that too, at an *absolutely Infinite Distance*, as is evident at first view; therefore the *other Two* must be opposite, in every other Quality but *Extension*, for tho' *extended Matter* be divisible by being *Extended*; yet *Space* is not actually to be divided; or one part of it separated from another. Since it is the *universal Locus* of, and penetrates all Bodies: And it is in *this* Sense, that the opposition of these two Qualities in *Body* and *Spirit*, is meant here.

Proposition XXIV.

By the *Analogy of Things*, and according to the Order of Nature, a *Spirit* is an *extended, penetrable, active, indivisible, intelligent Substance*.

*Demonstrat.* By Def. 2. *Matter* is an *extended, impenetrable, passive, unintelligent, divisible Substance*: And since by the *preceding Corollary*, *Matter* and *Spirit* are in every other Quality opposite, except in that of *Extension*; therefore in place of all the qualities in the *Definition of Matter*; putting their Opposits, excepting in that of *extended*

*extended* Substance, (for *Extension* must imply a Subject) and then a *Spirit* will become, according to the *Proposition*, an *extended, penetrable, active, indivisible, intelligent* Substance. I have chosen the Word *Intelligent*, in this, and it's opposite *Unintelligent*, in the other Definition. To wit, in that of *Body*, rather than that of *Thinking*, because *Intelligence* is the Source and Principle of *Thinking*, and expresses the *whole* of all the Faculties of *spiritual* Substances.

Corollary I.

Hence, in respect to their Substances only, a *material* Substance is an infinitely condensed, or incrasated, *spiritual* Substance: And on the other Hand, a *spiritual* Substance, is an infinitely rarify'd, or refin'd material Substance. As we have it in Holy Writ, there is a *natural* (or material) *Body*, and *there is a spiritual, and a glorified Body*. For since *Matter* and *Spirit*, have the Foundation of their Qualities common to both, to wit, an *extended* Substance: Since all their other Qualities are the one, respectively the Opposite or Negative of the other. Since *rarifying* any Quality in *Body* and *Spirit*, is subtracting from it's Intension and Energy, and therefore an infinite

nite Rarefaction of a Quality, is subtracting it intirely; and there being no *mean* between *Penetrability* and *Impenetrability*, between *Passivity* and *Activity*, *Divisibility* and *Indivisibility*, *Intelligence* and *Unintelligence*, they being contrary and Opposite; therefore, the infinite Rarefaction of the one Quality, is the Position of it's contrary; for tho' the finite *Subtraction* of a *negative* Quality (admitting no *mean*) puts nothing, yet the infinite *Subtraction* of such a *negative* Quality puts the *Affirmative* (thus  $- 02 \times - \ominus = + 0$ . but  $- \infty 0 \times - \ominus = + \ominus$ ) therefore in *Matter*, *subtracting infinitely*, all it's *positive* Qualities, or which is the same, (by the *preceding Corollary*) in *Matter*, *Subtracting infinitely*, the *negative* Qualities of *Spirit*, and then a *material* Substance will become a *spiritual* Substance; but since an infinite Rarefaction, of a contrary Quality, is the same with an *infinite Subtraction* of that contrary Quality, and since the same manner of Reasoning holds good in an *infinite Condensation*, of the Qualities in *Spirit*. Therefore in respect of their *Substances* only a *material* Substance, &c. q. e. d. The Case in short, as I conceive it, is thus. A *spiritual* Substance, when infinitely condensed and *incrassated*, looses it's Qualities of *Penetrability*, *Activity*, *Indivisibility*, and *Intelligence*. These being lock'd up, and as  
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it were *crampt*, in this *Condensation* of their *Substratum* (or the Substance in which they essentially inher'd,) thus *infinitely Compress'd*. The *Actuality* (as the *Metaphisicians* speak) of these *spiritual* Qualities being thus shut up and imprison'd, tho' their *Potentiality* be not quite destroyed, and thus a *crass, extended, impenetrable, passive, divisible, unintelligent* Substance is Generated, which we call *Matter*, but when this *Matter* thus form'd of a *spiritual* Substance, is again *infinitely* refin'd, and exalted, these *Powers*, and *Qualities* are unloosed, set at freedom again, and exert themselves as formerly, and thus become what they were originally made. But we must take care not to imagine that any *finite Subtilsation, Division, Refinement, or Exaltation* of gross *Brute-matter*, can in any the least degree, by any finite created Powers whatsoever, bring it to any but an infinitely distant Approach to this state of *Spirituality*; since it has been demonstrated, *in the first Chapter of this Part*, that no Finite how great soever, can be any finite Part, of any *relative Infinite* how small soever: No Power, less than his, *who out of the very Stones cou'd raise* (by Virtue of their original *Potentiality*) *Children to Abraham*, can out of *material*, bring *spiritual* Substances, or on the contrary, convert these into those.

Corol-

## Corollary II.

Since in ascending from *material* Substances, there can be no such thing, by the *Analogy* of Things and Order of Nature, as a *Jump* or *Leap*, from one extreme to another, without passing through the intermediate Steps; and since in *material* Things, there are Substances of all degrees of *Density*, and *Rarity*. *Earths* more Dense than *Water*, *Water* than *Air*, *Air* than *Ether*, *Ether* than *Light*. So in the *spiritual* World, there must be *Spirits* of all degrees of *Rarity*, the one *Sett* and Rank, more pure, and refin'd, than the other, in a perpetual *Scale*, 'till they ascend so near the *supreme Infinite*, as Creatures can approach their *Creator*, or *Finites* the *absolute Infinite*. And by the same *Analogy of Things*, as in the *material* World, these several Orders of Bodies, *Earth*, *Water*, *Air*, *Ether*, and *Light*, have their proper *Places*, *Elements*, and *Centers*, where they rest, and whether they tend, and out of which they cannot be detain'd but by *Violence*; so in the *spiritual* World, there are *Centers*, *Spheres*, and *Elements*, of several Orders of *Spirits*, the one more pure, and refin'd than the other, (the more pure still penetrating the less pure,) where they rest, and continue, to which  
by

by their *specifick* Degree of Purity, they are confin'd, out of which they cannot be detain'd but by *Violence*; all in a Subordination one to another, depending on their particular degrees of Purity, penetrating one another without Confusion or Contrariety, 'till they arrive as near as is possible to the *supreme Infinite*, who penetrates the whole *System* of Creatures.

### Corollary III.

Since by *Prop. 15.* the *Desires*, are the *Cardinal* Faculty of intelligent Beings, infinitely *Active*, and Powerful, belonging to that Principle in them, which is appropriated to the *spiritual* World. By these *Desires* therefore, those of the same *Element*, and same Degree of Purity, are enabled to communicate one with another: But since the more pure penetrate the less pure, but not *vice versa* (as is plain from *Corollary 1.* of the *preceding Proposition*;) the more pure may penetrate the less pure, contrary to their *Desires*; but not *vice versa*, this Superiority of the more pure, over the less pure, being a necessary consequence of the greater degree of Purity and Perfection. For as in the *material* World, the *Sun* purifies and rarifies Terrestrial Bodies, the nearer they approach, or are brought to him: And at  
last

last converts them into his Substance. So in the *spiritual* World, the *Sun's* Pattern, and *Architype*, the *Sun of Righteousness*, renders those *Spirits* the more pure penetrating (and as it were *Deities* their intimate Substances) whose *Elements* or Region is nearest him. By which, they more nearly partake of his Nature who penetrates the whole *System* of Beings.

Corollary IV.

Hence, since the *supreme Spirit*, in compounded intelligent Beings is more pure (as being the highest Principle; and that *Breath of Life*, which they had immediately from the Divine Substance) than the *rational Soul*, the *first* penetrates the *latter*, and the *latter* is but the *Medium*, and is it self but of an intermediate Nature, between the two *Extremes*, *Body* and *Spirit*, coupling them together by it's intermediate Substance. And in their primitive Order and Institution, they were in a due Subordination, one to another. The *Body* to the *rational Soul*, and *both* to the *supreme Spirit*: And in this Subordination, preserved and maintain'd, and diligently cultivated, according to their respective Dignity; in the *Will's* obeying, and approving of; and in the *whole Compound's* pursuing the practical Inferences deduced

duced in this *State*, did the *original Rectitude* of these compounded intelligent Beings consist. And in the Contrariety, Contradiction, and Rebellion, of these different *Principles*, one against another, in the *Will's* obeying, and approving of, and the *whole Compound's* pursuing, the practical Conclusion's deduced under this *State of Anarchy*, does the *Fall, Lapse, and Degeneracy* of this *Sett* of intelligent Beings consist. And for the restoring, rectifying and re-establishing the primitive Order and State, of these three Principles, to a habitual and lasting Subordination, was the Incarnation of the *Divine LOGOS*, and whole *Oeconomy* of the Redemption of Man.

Corollary V.

Hence, the *supreme Spirit*, may be Dark, Dead, and almost quite Obliterated, as to it's *ouvert Acts* (the *Principle* it self, being essential to, and interwoven with, the most intimate Natures of all intelligent Beings,) when the *rational Soul* is full of *Ideas*, *Pictures*, and *Images* of Things. And on the other hand the *supreme Spirit* may be full of *Light, Brightness, substantial Knowledge, Joy* and *Peace*. When the *rational Soul*, is but Weak, Faint, and Languid, and almost void of all *Ideas* and *Images*; these  
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being not only separable, but at last to be *actually* separated. (So far at least as the acts of the *rational Soul*, can affect the *supreme Spirit*.) when the LOGOS (that *eternal and essential Word of God*) which is *quick and powerful, and sharper than a Two-edged Sword, shall pierce, to the dividing asunder the Soul and Spirit.*

### SCHOLIUM GENERALE.

Thus I have endeavoured to give some faint, and imperfect Images, of the highest and most sublime Speculations of *Religion* and it's *Philosophy*, in the *preceding Propositions* and *Corollaries*. And tho' I am very far from thinking, they are even just, and compleat Images, and such as might be drawn from the same Principles, by a more skilful Hand. Yet I am fully convinced, the *Propositions* and *Corollaries* themselves, are true and just, as to their Substance; whatever may be in my way of explaining or demonstrating them; so far at least, as *Reason* can find out the *Truth* in such *sublime Mysteries*. I am also well satisfied, that *Reason* can with any propriety or justness, apply it self to Objects to which it is not *adequate* and appropriated, after no other manner, but by supposing those Objects, to which it is *adequate, Images*

ges or Representations, of those other Objects, to which it is not adequate. There being no other possible way for *Reason* to find a *Medium* of it's Knowledge, of Objects that are convey'd to the rational Understanding, by none of the bodily Senses. (as the proper Objects of it's Faculties are.) And there being an absolute necessity, from the *simplicity* and *uniformity* of the *Divine Nature*, and of his manner of Operating, that all his Works shou'd be Resemblances and *Images* one of another, (more or less perfect, according to their respective Natures,) and also of himself, their *original Pattern* and *Architype*. This manner of Reasoning, and this *Medium* of rational Knowledge, duly instituted, must be just and true, as far as it reaches. And thus far *Reason* can go, and not one step further, in the Knowledge of superior Objects; it can frame and form *Images* of these superior Objects, from what it finds and certainly knows of the *material* World, to which it is in some measure adequate. *Images* I say, not *Metaphorical* only, but *Real* and *Physical*, as a Statue represents a Man, a Picture in *Miniature*, one from the Life, as a *Seed* (which is really the plant it self in little) does a grown plant, or an *Embryo*, the adult Animal: This is the Boundary of *Reason* in these superior Objects. And it is very obser-

observable, that there are various Images in Nature, and in the *intellectual Species* of Things (fram'd upon what the Senses have already convey'd into the rational Understanding) of all the most unconceivable, the most abstruse, and sublime *Mysteries* of Religion and it's Philosophy; each superior to another. Can there be a more perfect, noble, or lively Image in this lower World, of the *Divine Nature, Light, Benignity, Greatness, and Power* required, than that of the *Sun*, in respect of our *Planetary System*. His Beams shine, and are transmitted through all the *Planetary and Cometary Regions*, even into the *Systems* of the *fix'd Stars*. He *attracts* all the *Planets and Comets* in our *System*, and is the Source of all their regular, uniform, and constant *Motions and Influences*. He warms, cheers, enlivens, and fertilises all the *Elements, Vegetables, and Animals*; and is indeed the *material Deity* of this inferior World. Is there not a plain and obvious Image of the **EVER-BLESSED-TRINITY IN UNITY**, in every Order of Creatures? In the three Dimensions of Bodies? In Nature's never rising above the *Third Dimension* in her regular Operations as was shown in *Scholium Prop. 12*? In the *Three infinite Powers* of *universal Space*? In the *Three general Divisions* of Objects? *Matter, created Spirit,*

*Spirit*, and the *Supreme Infinite* in the *three Distinctions* and *Universal Principles* that comprehend the whole of material Intelligent Beings? The *Faculty*, *Object*, and the *Congruity* or *Incongruity* between these? The *Profane* and *Ignorant* may make a Jest of this *Ternary Chain*, and ascribe it to *Chance* or *Fortune*. But the *Analogy of things*, and the regular *Uniformity* in *Nature*, make it evident to a *Demonstration*; that it must have had its *Rise* in its *Original Pattern* and *Architype*, the *Divine Nature*. Even the *Eternal Generation* of the *Second Principle* in the *Godhead*, of the *First*, and the *Eternal Procession* of the *Third Principle* from the *First* and *Second*, comes evidently out of this *Analogical Ternary*, when elevated to its *Origin* in the *Divine Nature*; as was shewn in *Scholium 2. Prop. 17.* And the impossibility of increasing or multiplying the *Divine and Supreme Infinitude*, even by itself, so far as that it is incapable of *Increase*, or *Diminution*; as was shewn in *Corollary 2. Prop. 12.* pictutes forth, the *Unity* of the *Divine Nature*, in these *three Relations* of the *whole* to the *whole*. How noble a *Representation* in *Created things*, is the *Universal Space* of the *Divine Ubiquity*, *Infinitude*, and *Spiritual Nature*? how lively a *Picture* in the *Intellectual Species* of things, of *Creation*, or of *Gods producing* the things that be, out of the things that were not, is that *Proposition Demonstrated Corollary 2. Prop. 2.*

$$\times 0 = \infty \quad \times 0 = 1. \text{ or } \frac{1+1+1+1+1+1 \text{ \&c.}}{\infty} \times$$

$o = \infty$   $\odot \times o = \odot$ ? The production of a *Plant* from its *Miniature* in the *Seed*; and of an *Animal* from an *Animalcule*, is an astonishing Representation of the Resurrection of the Body. These and many such Resemblances, and Images in Nature, in the *Sensible* and *Visible* things, and in the *Intellectual Species* of things, derived through the Senses; might be brought to illustrate and confirm the greatest Difficulties and most abstruse Mysteries of *Religion*, and its *Philosophy*. So certain and universal is the *Beautiful Analogy of Things*, and so careful has the *Kind and Bountiful Author* of our Beings been, to supply us with Evidences in our *lower Faculties*, and *lapsed Estate*, of those *Truths* he requires us to believe and receive. The *full and compleat Conception and Knowledge* of which, belong not but to our *Superiour Faculties*, and to our *Restored and Re-established Estate*. May we then use the *Assistances, Reason*, and the *Divine Bounty*, has afforded us, (I may almost say, even beyond and out of their *Natural Order*) for increasing our *Faith*, Cultivating and expanding our *Superiour Faculties*, rescuing us out of our *Degeneracy and Corruption*, into the *Glorious Liberty of the Sons and Children of God*, and then, *in his Light we shall see Light*, Amen.

C H A P. III.

Of the USE of the Arithmetick for Infinites.

¶ I. **I**N Arithmetical Progression; in which let  $a$  denote the first,  $v$  the last term,  $x$  the Difference,  $t$  the Number of Terms, and  $z$  the Sum of all the Terms, which in an ascending Progression are  $a, a + x, a + 2x, a + 3x, \&c.$  but in a descending Progression  $a, a - x, a - 2x, a - 3x, \&c.$

Having any three of these five  $a, v, x, t, z.$  you may find the other two by help of these two Lemma's,

Lem. 1.  $\{v = a + tx - x\}$  but  $v = a - tx + x,$

Lem. 2.  $\{2z = t \times a + v\}$  when it descends.

I shall here only treat of ascending Progressions, judging those that descend as not properly belonging to the Arithmetick of Infinites.

Now in ascending Progressions both  $t$  and  $v$  are infinite.

Therefore Corol 1.  $\{v = tx\}$  in the Case of  
And Corol 2.  $\{2z = tv\}$  Infinites.

Because Infinites are not all equal, but vary in their Ratio's to one another, as much as finite Quantities do; therefore to avoid confusion, I suppose  $v = \infty \times 1 = 1 + 1 + 1 + 1 + 1 + 1 \&c.$

So from Corol. I.  $t = \frac{\infty}{x} = \infty \times \frac{1}{x} = \frac{1}{x}$

$+ \frac{1}{x} + \frac{1}{x} + \frac{1}{x} + \frac{1}{x} + \frac{1}{x} \&c.$

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Prop. 1.  $z = \frac{\infty^2}{2x}$ . This follows from substitu-

ting the Value of  $t$ , viz.  $\frac{\infty}{x}$  in Corol. 2.

Exemp. 1. Let  $x = 1$ . then  $1 + 2 + 3 + 4 + 5 \&c. = z = \frac{\infty^2}{2}$ , that is, the Sum of all

the natural Numbers continued in *infinitum* is equal to half the Square of Infinite: and here it is to be noted, that in this Case only  $t = v = \infty \times 1 = 1 + 1 + 1 + 1 + 1 \&c.$

Exemp. 2. Let  $x = \frac{1}{2}$ , then  $1 + 1\frac{1}{2} + 2 + 2\frac{1}{2} + 3 + 3\frac{1}{2} \&c. = z = \infty^2 =$  to the Square of Infinite.

And thus may you find the Ratio between the Sum of any ascending Arithmetical Progression, and the Square of Infinite; and Note that by Infinite, is always understood Infinite in General, or Infinite of the simplest Nature and Lowest Degree,  $1 + 1 + 1 + 1, \&c.$  unless it be otherwise expressly declared.

Corol.  $\infty \times \frac{1}{\sqrt{2x}}$  is the Root of a Square,

which Square is equal to the Sum of any Arithmetical Progression ascending in *infinitum*.

Exemp. Let  $x = 2$ , then  $\infty \times \frac{1}{2}$  (or an infinite number of  $\frac{1}{2}$ ) is the Root of a Square equal to the Sum of that Progression, viz.  $1 + 3 + 5 + 7 \&c. = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} \&c. |^2$

Corol.

*Corol. 2.* Let  $a = \infty n$ ,  $v = \infty m$ .  $t = \infty p$ .  
 These values of  $a, v, t$ , being substituted in  
*Lem. 2.* will give you  $z = \infty p \times \infty n + \infty m$   
 $= \infty^2 \times pn + pm$ , or  $z = \frac{\infty^2 \times pn + pm}{2}$ , and

the common Difference  $x = \frac{m - n}{p}$ , as you may  
 easily find from *Lem. 1.*

You may express the Sum  $z$  otherwise, for  
 $t = \frac{v - a}{x}$  by *Lem. 1.* Therefore  $\frac{v - a}{x} \times$   
 $v + a = 2z$  by *Lemma 2d.* that is  $z = \frac{v^2 - a^2}{2x}$   
 $= \frac{\infty^2 m^2 - \infty^2 n n}{2x} = \frac{\infty^2 \times m m - n n}{2x}$ ,

*Corol. 3.* From *Prop. 1.* and *Corol. 2.* it is  
 evident that in two Arithmetical Progressions  
 having the same common Difference  $x$ , the Sum  
 of that whose terms are infinite, is to the Sum  
 of that whose terms are finite, as  $m^2 - n^2$  to 1.  
 For the Sum of the first, by *Corol. 2.* is  $\infty^2 \times$   
 $\frac{m^2 - n^2}{2x}$ ,  $\times$  the Sum of the other, by *Prop. 1.*  
 is  $\infty^2 \times \frac{1}{2} x$ .

*Corol. 4.* From hence may be solved this Pro-  
 blem. Any Arithmetical Progression being gi-  
 ven as  $a, a + x, a + 2x, a + 3x, \&c.$  whose terms  
 are finite; to find another consisting of infinite

Terms, that shall have the same Difference  $x$ , and whose Sum shall be equal to the Sum of the given Progression. *Solution.*  $m^2 - n^2 = 1$  from *Corol* 3. & *ex hypothesi*. Therefore  $m^2 = 1 + n^2$ ; so to find  $m$  and  $n$ , is an indetermin'd Problem, whose Solution by the known Me-

thods will give you  $m = \frac{e^2 + 1}{e^2 - 1}$ ,  $n = \frac{2e}{e^2 - 1}$ ,

where  $e$  is any number ( $> 1$ ) taken at Pleasure. So then these Values of  $m$  and  $n$  being substituted in the Values of  $a$  and  $v$ , of *Corol*. 2.

will give you the first Term  $a = \infty \times \frac{2e}{e^2 - 1}$ , and

the last  $v = \infty \times \frac{e^2 + 1}{e^2 - 1}$ , and calling the com-

mon Difference  $x$ , you will have a Progression, each of whose terms is infinite, and whose Sum shall be equal to the Sum of any other Arithmetical Progression, whose first term is finite, and the common Difference  $x$ ; and because  $e$  is an Arbitrary number, therefore you have as many of such Progressions as you please, to answer the *Problem*.

*Exemp.* Let the given Progression be  $1 + 2 + 3 + 4 + 5$  &c. where  $x = 1$ , so the Sum thereof is  $= \infty^2 \times \frac{1}{2}$  (as in *ex.* 1. *Prop.* 1) now taking

$e = 2$ , you will have  $n = \frac{2e}{e^2 - 1} = \frac{4}{3}$  &c.  $m =$

$\frac{e^2 + 1}{e^2 - 1} = \frac{5}{3}$ , which from the second expression of

of *Corol. 2.* will give the Sum of the series  
 $(\infty \times \frac{4}{3}, 1 + \infty \frac{4}{3}, 2 + \infty \frac{4}{3}, 3 + \infty \frac{4}{3}, \&c.)$

$$\infty^2 \times \frac{m^2 - n^2}{2x} = \infty^2 \times \frac{\frac{25}{9} - \frac{16}{9}}{2x} = \infty^2 \times \frac{1}{2}, \text{ which is}$$

the same with that of the given Progression consisting of finite terms.

*Schol.* The Problem may be made more general, and the Solution as easy, if it were required, that the Sum of the Series consisting of infinite Terms, should be to that of the other consisting of finite Terms in any given Ratio of  $r^2$  to  $s^2$ , for then it must be to find  $m$  and  $n$ , such that  $m^2 - n^2, 1 :: r^2 : s^2$ .

*Prop. 2.* Let all things be as in *Prop. 1.* except the last Term, which here we shall suppose  $v =$

$$\infty n, \text{ in which Case I say } \left\{ z = \infty^2 \times \frac{nn}{2x} \right\}$$

*Exemp 1.* Let  $n = 2, x = 1; a = 1$ , so the Progression will be 1, 2, 3, 4, 5, &c. till the last Term be  $\infty 2$ , I say the Sum  $1 + 2 + 3 + 4 + 5, \&c. = z = \infty^2 \times 2 =$  double the Square of Infinite.

*S. II.* In Geometrical Progression, let  $a$  denote the first, and  $v$  the last Term, the Ratio of the Terms, that of  $r$  to  $s$ ,  $t$  the Number, and  $z$  the Sum of all the Terms of any Geometrical Progression, which will be  $a, \frac{sa}{r}, \frac{s^2 a}{r^2}, \frac{s^3 a}{r^3}, \frac{s^4 a}{r^4}$ .

Of these five things, *viz.* the first Term  $a$ , the last Term  $v$ , the Ratio of the Terms  $\frac{r}{s}$ , the

number  $t$ , and the Sum of the Terms  $z$ , having any three, you may find the other two by these two *Lemma's*.

$$\left. \begin{aligned} \text{Lem. 1. } v &= \frac{s^{t-1}}{r^{t-1}} \times a \\ \text{Lem. 2. } sz + ra &= rz + sv \end{aligned} \right\}$$

From *Lemma 2d.* it follows that  $z = \frac{ra - sv}{r - s}$

when the Progression descends, that is, when  $r < s$ .

But when the Progression ascends, that is, when  $r > s$  then from *Lemma II.* it will

$$\text{be } z = \frac{sv - ra}{s - r}$$

*Case 1.* In descending Progressions where the number of Terms are infinite, the last Term  $v$  will be  $= 0$ .

*Prop. 1.* In all descending Progressions, whose number of Terms are infinite, and first Term finite, the Sum of the Progression is a finite quantity viz.

$$z = \frac{ra}{r - s}$$

*Corol. 1.* Let  $a = r$ , then  $z = \frac{r^2}{r - s}$

*Exemp.* Let  $r = 1$ ,  $s = \frac{1}{2}$ , then  $1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} \text{ \&c.} = z = \frac{1^2}{1 - \frac{1}{2}} = 2$

*Prob.* Having the first Term  $a$ , and the Ratio of the Terms  $\frac{r}{s}$  of any Geometrical Progression

ffion descending in *infinitum*, till  $v = 0$ , to find another Progression descending in *infinitum*, whose first Term shall be any given number  $b$ , and its Sum equal to the Sum of the given Progression.

*Sol.* Let  $m$  to  $n$  be the Ratio of the Terms of the Progression sought; now  $\frac{r a}{r - s}$  is the Sum of the given Progression, by *Prop. 1.* and for the same reason  $\frac{m b}{m - n}$  must be the Sum of the Progression sought, therefore from the condition of the Problem sought  $\frac{m b}{m - n} = \frac{r a}{r - s}$ , which gives  $n = \frac{m \times r a - r b + s b}{r a}$ , where  $a, r, s, b$  are

given, and  $m$  may be taken at Pleasure; and so you have  $n$  from this Equation; and consequently the Progression sought is found; for a Progression is found, when you have the first Term  $b$ , and the Ratio of the Terms  $m$  to  $n$ .

*Example.* Let  $r = 1$ ,  $s = \frac{1}{2}$ ,  $a = 1$ ;  $b = \frac{1}{2}$ , I assume  $m = \frac{1}{2}$  ( $= b$ ) so the Equation will give  $n = \frac{4}{3}$ , therefore  $1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \&c. = \frac{1}{2} + \frac{1}{4} + \frac{1}{8} \&c.$

And here it is to be noted that since  $m$  is taken at Pleasure, the Problem is indetermined, and so you may find as many Progressions as you please, whose Sum shall be equal to the Sum of any given Progression.

*Schol.* The Problem will be more general, if it

it be required that the Sum of the given Progression  $\frac{ra}{r-s}$  be to the Sum of the Progression

sought  $\frac{mb}{m-n}$  in any given Ratio  $h$  to  $k$  viz.

$$\frac{ra}{r-s} : \frac{mb}{m-n} :: h : k, \text{ which gives } z = \frac{m \times a \ r k + b h s - b h r}{a k r}; \text{ where } m \text{ is at Pleasure.}$$

Case II. In ascending Progressions, whose number of Terms are Infinite, the last Term  $v$  will be  $= \infty \times e$ ; but first I shall consider these Progressions in which  $e = 1$ , that is, where the last Term is an infinite number of Units.

Prop. 2.  $z = \infty \times \frac{s}{s-r} (= \frac{sv}{s-r})$  for  $r a$

vanishes, because  $a$  is finite, and  $v$  infinite.

But here it is carefully to be observed, that in all these Progressions it is necessary to make  $a = r$ , so that  $r$  will be the first and  $s$  the second Term of the Progression; and indeed in all Geometrical Progressions, there is a convenience of expressing the Ratio of the Terms by the two first Terms of the Progression.

This being premised, it is evident that  $\frac{s}{s-r}$  is the infinitely small and equal part, of which an infinite number gives the Sum of any Geometrical Progression ascending in *infinitum*.

Examp.

*Examp. 1.* Let  $r = 1$ ,  $s = 3$ , then  $\frac{s}{s-r} = \frac{3}{3-1} = \frac{3}{2}$ , which shews  $z = \infty \times \frac{3}{2}$ , that is  $1 + 3 + 9 + 27 + 81 \&c. = \frac{1}{2} + \frac{3}{2} + \frac{9}{2} + \frac{27}{2} \&c.$

*Examp. 2.* Let  $r = 1$ ,  $s = \frac{3}{2}$ , so  $\frac{s}{s-r} = \frac{\frac{3}{2}}{\frac{3}{2}-1} = 3$ , Ergo  $z = \infty \times 3$ , that is,  $1 + \frac{3}{4} + \frac{27}{8} + \frac{27}{16} \&c. = 3 + 3 + 3 + 3 \&c.$

*Problem.* To find a Progression, which shall have any given number ( $a$ ) for the equal part of which its Sum consists. *Solution.* Let  $r$  be the first, and  $s$  the second Term of the Progression

sought, then (because  $\frac{s}{s-r}$  is the equal part for every Progression)  $\frac{s}{s-r} = a$  which gives  $s =$

$\frac{r a}{a-1}$ , so taking the first Term  $r$  at Pleasure,

the second shall be  $\frac{r a}{a-1}$ .

*Examp.* To find a Progression whose Sum shall be  $= \infty \times 2$ . In this Case  $a = 2$ , so ta-

king  $r = 1$ , it will give  $\frac{r a}{a-1} = 2$  which shews

that the Sum of a Progression, whose first Term is  $1$ , and second Term is  $2 = \infty \times 2$ , or  $1 + 2 + 4 + 8 \&c. = 2 + 2 + 2 + 2 \&c.$

*Scholium.*

*Scholium.* Because  $r$  is taken at Pleasure, therefore you may find as many Progressions as you please, whose Sums shall be all equal, because each of them is  $= \infty \times a$ .

*Prob. 2.* Having any Progression ascending, to find another whose Sum shall be equal to the Sum of the given one. Let  $r$  be the first,  $s$  the second Term of the given Progression; and  $m$  the first,  $n$  the second Term of the Progression

sought, then  $\infty \times \frac{s}{s-r}$  is the Sum of the gi-

ven one, and  $\infty \times \frac{m}{m-n}$  is the Sum of the Pro-

gression sought, Ergo  $\infty \times \frac{s}{s-r} = \infty \times \frac{m}{m-n}$ ,

or  $\frac{s}{s-r} = \frac{m}{m-n}$  which gives  $n = \frac{r m}{s}$ ,  $m$  may

be taken at Pleasure, and so you have  $n$ .

*Schol.* So may you find a Progression, whose Sum shall be to the Sum of the given one, in

any given Ratio  $b$  to  $k$ . for then  $\frac{m}{m-n} : \frac{s}{s-r} ::$

$b : k$ : so that  $n = \frac{m \times s b + r k - s k}{s b}$ .

§ III. Before I proceed to other Progressions, it will be necessary to subjoin some things, which were omitted in § I. concerning Arithmetical Progression, and which should have immediately pre-

preceeded § 2.

*Lemma.*  $z = \infty^2 \times \frac{1}{2x}$ , when  $v = \infty \times 1$ . by

*Prop. 1.* of § 1.

*Prob.* Having the common Difference  $x$ , and the last Term  $v = \infty \times 1$  of any Arithmetical Progression ascending in *infinitum*; to find another Arithmetical Progression, whose Sum shall be equal to the Sum of the given one.

Let  $e$  be the common Difference,  $\infty \times n$  the last, and  $y$  the Sum of all the Terms of the Pro-

gression sought; then  $y = \infty^2 \times \frac{nn}{2e}$ : by *Prop. 2.*

of § 1. Now because  $z = \infty^2 \times \frac{1}{2x}$  is the Sum

of the given Progression, therefore from the

condition of the Problem  $\frac{1}{2x} = \frac{nn}{2e}$ , so  $e = x$

$nn$ ; you may take  $n$  at Pleasure, and so you have  $e$  and consequently the Progression sought.

*Exemp. 1.* Let the given Progression be 1, 2, 3, 4, 5, &c. to  $\infty \times 1$ . where  $x = 1$ , so  $e = nn$ ; calling  $n = 2$ , you have  $e = 4$  for the common Difference of the Progression sought, viz. 1, 5, 9, 13, &c. to  $\infty \times 2$ . I say then that the Sums of these two Progressions are equal.

*Corol.*  $n = \sqrt{\frac{e}{x}}$ , so taking  $e$  at Pleasure, you

have  $n$ , as in the former Example, if you call  $e$ ,

2, then  $n = \sqrt{2}$ , so the Progression sought is, 1, 3, 5, 7, &c. to  $\infty \times \sqrt{2}$ , whose Sum shall be equal to 1 + 2 + 3 + 5 + 6 &c. to  $\infty \times 1$ . So that in solving this Problem, you may either make the common Difference, or the infinitely small part ( $n$ ) of the last Term, what you please; and because one of the two may be taken at Pleasure, therefore the Problem is indetermined, and consequently you may find as many Progressions as you please, whose Sums shall each of them be equal to the Sum of the given Progression.

*Scholium.* In the same manner you may find as many Progressions as you please, the Sum of each of which shall be to the Sum of the given one in any given Ratio of  $k$  to  $b$ ; for then  $\frac{n n}{2 e}$ :

$\frac{1}{2 x} :: k : b$ , which gives  $k e = b x n^2$ ; so that of these two ( $e, n$ ) taking one at Pleasure, you have the other from this Equation.

*Problem 2.* Having the Sum  $\infty^2 \times q$  of any Progression, to find another that shall have a given common Difference  $e$ , and whose Sum shall be equal to the given Sum. Let  $\infty \times n$  be the last Term of the Progression sought, then its

Sum will be  $= \infty^2 \times \frac{n^2}{2 e}$ ; therefore by the

condition of the Problem  $\frac{n^2}{2 e} = q$ . so that  $n =$

$$\sqrt{2 e q}:$$

$\sqrt{2eq}$  : but,  $e$  and  $q$  are given, therefore  $n$  is known.

*Examp.* Let  $q = 1$ , it is requir'd to find a Progression whose Difference shall be 1, and its Sum  $= \infty^2 \times 1$  or the Square of infinite; now because  $q = 1$ , and  $e = 1$ , therefore  $n = \sqrt{2}$ , so that  $\infty \times \sqrt{2}$  shall be the last Term of a Progression 1, 2, 3, 4, 5, 6, 7, &c. whose Sum shall be  $= \infty^2$ ; but by *Examp.* 2d. of *Prop.* 1. of  $\S$  1. if  $x = \frac{1}{2}$ , and  $v = \infty$ , then the Sum  $z = \infty^2$ ; Ergo  $1 + 2 + 3 + 4 + 5$  &c. to  $\infty \times \sqrt{2} = 1 + 1 \frac{1}{2} + 2 + 2 \frac{1}{2}$  &c. to  $\infty \times 1$ .

*Examp.* 2. Let  $q = \frac{1}{2}$ , and  $e = 2$ , then  $n = \sqrt{2}$ , so that a Progression whose common Difference is 2, and last Term  $\infty \times \sqrt{2}$  shall have its Sum  $= \infty^2 \times \frac{1}{2} =$  (by *ex.* 1. *pr.* 1.)  $1 + 2 + 3 + 4 + 5$  &c. to  $\infty$ .

$$\begin{aligned} \S \text{ V. Lemma } & \frac{1}{1-r} e = 1 + er + \frac{e \times e + 1}{2} \\ & \times r^2 + \frac{e \times e + 1 \times e + 2 \times r^3 + e \times e + 1 \times e + 2}{2 \times 3} \\ & \times \frac{e + 3}{4} \times r^4 + \frac{e \times e + 1 \times e + 2 \times e + 3 \times e + 4}{2 \times 3 \times 4 \times 5} \\ & \times r^5 \text{ \&c.} \end{aligned}$$

Let us now consider the various Progressions that will arise out of this Series, and what relation they have to infinite in general or  $\infty \times 1$ , and that I may proceed distinctly, I will resolve it into several Cases, beginning at the Simplest, where  $r = 1$ , and so proceed gradually to  $r = 2$

$r = 3$

$r = 3$ , &c. And where the Series is neither in an Arithmetical nor yet in a Geometrical Progression, I shall endeavour to discover according to what increase the Progression goes on; tho' in general that is plain enough from the Lemma of § 5.

Case 1. Let  $r = 1$ , which contains an infinite number of other Cases, according to the Different values of  $e$ , the Progression whereof I shall show in the following Articles.

$$\text{Artic. 1. } (e = 1) \frac{1}{1-1} = 1 + 1 + 1 + 1 \text{ \&c.} \\ = \infty \times 1.$$

$$\text{Artic. 2. } (e = 2) \frac{1}{1-1} 2 = 1 + 2 + 3 + 4, \text{ \&c.} = \infty^2$$

$$\text{Artic. 3. } (e = 3) \frac{1}{2-1} 3 = 1 + 3 + 6 + 10 \text{ \&c.} = \infty^3$$

$$\text{Artic. 4. } (e = 4) \frac{1}{1-1} 4 = 1 + 4 + 10 + 20 \text{ \&c.} = \infty^4$$

Now you are to observe that the Terms of any one of these Progressions is made up the of Sum of the Terms of the Progression next preceeding; for instance, the third Term of the Progression  $\infty^3$  viz. 6, is the Sum of the three first Terms of the Progress  $= \infty^2$ ; in like manner the fourth Term (20) of Progression in Article fourth, is the Sum of the

the four first Terms in the Progression of *Art. 3d.* and the 7th Term of *Art. 3d.* is the Sum of the Seven first Terms in *Art. 2d.* It is to be observed likewise that the Terms of *Art. 3d.* are *Triangular Numbers*, since they are the Sums of the Natural Numbers of *Art. 2d.* and consequently the Sum of the *Triangular* Progression continued in *infinitum*, is equal to the *Cube* of Infinite. *Case 2d. r = 2.*

$$\text{Art. 1. } e = 1, \text{ then } \frac{1}{1-2} = 1 + 2 + 4 + 8, \text{ \&c.} = \infty \times 2.$$

$$\text{Art. 2. } e = 2, \text{ then } \frac{1}{1-2} 2 = 1 + 4 + 12 + 32, \text{ \&c.} = \infty^2 \times 4.$$

$$\text{Art. 3. } e = 3, \text{ then } \frac{1}{1-2} 3 = 1 + 6 + 24 + 80, \text{ \&c.} = \infty^3 \times 8.$$

$$\text{Art. 4. } e = 4, \text{ then } \frac{1}{1-2} 4 = 1 + 8 + 40 + 160, \text{ \&c.} = \infty^4 \times 16.$$

*Note,* that the Terms of *Art. 1st.* are in a *Geometrical Progression* in the Ratio of 1 to 2:

And it is observable that the terms of any following *Article* is made by the multiplication of the Terms of *Art. 1st.* into the respective Terms of that *Article* in *Case 1.* where *e* has the same Value. For instance the third Term of *Article 2,* is the Product of the third Term of *Artic.*

1. into the third Term of *Artic. 2.* of *Case 1.* and the fourth Term (*viz.* 160) is the Product of the fourth Term (*viz.* 8.) of *Artic. 2.* into the 4th Term (*viz.* 20) of *Artic. 4th. Case 1st.* And universally, let *A* denote any Term in any *Artic.* of *Case 1.* *B* any Term in *Artic. 1st* of *Case 2d.* And *C* any Term in any of the following *Articles* of *Case 2d*; I say  $C = AB$ , taking  $ABC$  in the same order *i. e.* if *C* be the 5th Term, then *A* and *B* must also be the 5th Terms of their Progressions, and whatever Value (*e*) has in the Progression of which *C* is the Term, it must have the same in that Progression where *A* is the Term: *Examp.* To find the 7th Term of *Artic. 3.* of *Case 2.* Here *C* denotes the 7th Term of a Progression in which  $e = 3$ : this shews that *A* is the 7th Term of *Artic. 3. Case 1st*, which multiplied into the 7th Term *B* of *Artic. 1. Case 2d* will give *C* the Term sought.

*Case 3d. r = 3*

$$\text{Art. 1. } e = 1, \text{ then } \frac{1}{1-3} = 1 + 3 + 9 + 27$$

$$\&c. = \infty \times \frac{1}{2}.$$

$$\text{Art. 2. } e = 2, \text{ then } \frac{1}{1-3} | 2 = 1 + 6 + 27$$

$$+ 108, \&c. = \infty^2 \times \frac{2}{4}.$$

$$\text{Art. 3. } e = 3, \text{ then } \frac{1}{1-3} | 3 = 1 + 9 + 54 +$$

$$270, \&c. = \infty^3 \times \frac{27}{8}.$$

*Art.*

Art. 4.  $e = 4$ , then  $\frac{1}{1-3} 4 = 1 + 12 + 90 + 540, \&c. = \infty \times \frac{81}{16}$ .

Note, the first Series is a geometrical Progression going on in the Ratio of 1 to 3. And the following Progressions are made out of this first, with the respective ones of those in Case 1<sup>st</sup> in all respects, as those of Case 2<sup>d</sup> already explain'd: for let  $A$  be any Term in any Artic. of Case 1.  $B$  a Term of the same order (with  $A$ ) in Artic. 1. Case 3. and  $C$  a Term of the same order in any of the Articles of Case 3<sup>d</sup>. I say  $C = AB$ , where  $e$  has the same Value in  $A$  that it has in  $C$ . And so it is for all the succeeding Cases in infinitum: The first Series of any case,  $r$  (viz. where  $e = 1$ ) is always a geometrical Progression in the Ratio of 1 to  $r$ ; the following Progressions are made by the Multiplication of the Terms of this first Series into the respective Terms of those in Case 1. As has been shewn in Case 1 and 2<sup>d</sup>.

Scholium. To have the first Progression of every Case, let  $e = 1$ , then  $\frac{1}{1-r} = 1 + r + r^2 + r^3 + r^4 + r^5 \&c.$

But  $1 + r + r^2 + r^3 + r^4 \&c. = \infty \times \frac{r}{r-1}$

$\frac{r}{r-1} + \frac{r}{r-1} + \frac{r}{r-1} + \frac{r}{r-1} \&c.$

L 2

Before

Before I conclude this Subject, it will be necessary to remove a very obvious and material Objection, *viz.* how it comes to pass that the Sum of the natural Numbers  $1 + 2 + 3 + 4 + 5, \&c.$  should be equal to  $\frac{\infty^2}{2}$  or half the

Square of Infinite, as it appears by *Ex. 1.* of *Prop. 1.* of  $\S 1.$  And yet the same Sum is  $= \infty^2$  or the whole Square of infinite, as appears by *Art. 2d.* of *Case 1.* of the last *Lemma.* This seeming contradiction may be reconciled, if we suppose  $\infty \times 1$  to be the last Term in the Progression of *ex. 1. prop. 1. § 1.* which will make the Sum  $\frac{\infty^2}{2}$ ; and  $\infty \times \sqrt{2}$  to be the last

Term in the Progression of *Art 2d.* of *Case 1.* of the last *Lemma*; for that will make the Sum of the Progression  $= \infty^2$ , as appears by *ex. 1.* of *prob. 2. § 3.* So that tho' it be the same Progression going on in *infinitum*, yet the one goes on to a greater Infinite, *viz.*  $\infty \times \sqrt{2}$  than the other which ends at  $\infty \times 1.$

But the plain way of reconciling the Matter depends on the common Rules of Multiplication.

For  $1 + 2 + 3 + 4 + 5 \&c. = \frac{1}{1-1} 2 = \frac{1}{1-1}$   
 $\times \frac{1}{1-1}$ , but  $\frac{1}{1-1} = 1 + 1 + 1 + 1 \&c.$  and  
 therefore  $1 + 2 + 3 + 4 + 5 \&c. = 1 + 1 + 1 + 1 + 1 \&c. \times 1 + 1 + 1 + 1 + 1 \&c.$

Let

Let us now make an actual Multiplication of six Terms only, thus

$$\begin{array}{r}
 1 + 1 + 1 + 1 + 1 + 1 \\
 1 + 1 + 1 + 1 + 1 + 1 \\
 \hline
 A. 1 + 1 + 1 + 1 + 1 + 1 B. \\
 1 + 1 + 1 + 1 + 1 + 1 \\
 1 + 1 + 1 + 1 + 1 + 1 \\
 1 + 1 + 1 + 1 + 1 + 1 \\
 1 + 1 + 1 + 1 + 1 + 1 \\
 C. 1 + 1 + 1 + 1 + 1 + 1 D \\
 \hline
 1 + 2 + 3 + 4 + 5 + 6 + 5 + 4 + 3 + 2 + 1
 \end{array}$$

From the Process it is evident, that adding the several Columns, their Sums make 1, 2, 3, 4, 5, 6, which is the greatest, viz. BC (from which they descend in the same order to D) and this BC is always the number of Units in each Factor, so that if the number of Units multiplied into it self, had been 1000, then BC the last Term of the Progression ascending from A would have been 1000; and consequently if the number of Units multiplied into it self had been  $\infty \times 1$ , then BC the last Term of the Progression would have been  $\infty \times 1$ . Now the Progression descends from BC to D in the same Order as it ascends from A to BC; But ABC is the Sum of the Progression 1, 2, 3, 4, 5, 6, &c. ending at BC =  $\infty \times 1$ ; and

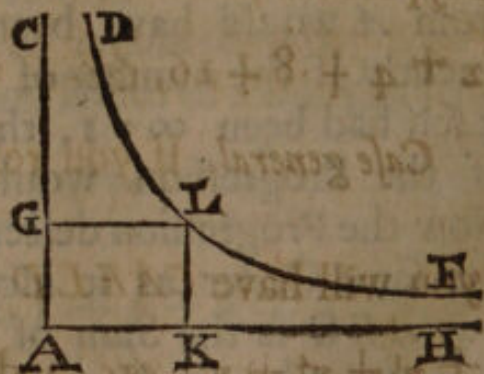
this Sum  $ABC$  is but half the Product (of which  $BCD$  is the other) that is to say, half the Square of Infinite: Thus you see that the Process of *Art. 2.* of Case 1. agrees exactly with that of *Prop. 1.* of § 1. only that of *Art. 2.* Case 1. gives you the Progression twice over, and so makes it double of what it is in *Ex. 1. Prop. 1. § 1.*

*Schol.* From this Solution it appears that the Sum of the Progression in *Art. 3.* Case 1. viz.  $1 + 2 + 3 + 6 + 10 + 21 \&c.$  is not precisely  $\infty^3$  or the Cube of Infinite; for  $\frac{1}{1-1} \times \frac{1}{1-1} \times$

$\frac{1}{1-1} = \frac{1}{1+1+1+1 \&c.} \times \frac{1}{1+1+1+1 \&c.} \times \frac{1}{1 \&c.} \times \frac{1}{1+1+1+1 \&c.}$  contains that Progression oftner than once; and the same is to be considered in all the Progressions, except when  $e = 1$ .

§ VI. The Arithmetick of Infinites applied to Quadratures of Curvilinear Spaces.

Let  $DLF$  be any of the Hyperbola's, whose Asymptots are  $AC, AH$ , let  $AK = x, KL = y$ , and the Equation comprehending all the Hyperbola's  $yx^n = 1$ .



By

By the common Methods

$$\left. \begin{aligned} CAKLD &= \frac{1}{1-n} \times x^{1-n} \\ HAGLF &= \frac{n}{n-1} \times x^{1-n} \end{aligned} \right\}$$

And also

Corol. I. Let  $x=1$ , then  $CAKLD = \frac{1}{1-n}$ ,

and  $HAGLF = \frac{n}{n-1}$

Case I. Let  $n=1$ , so the Equation will be  $yx=1$  for the common Hyperbola, in which  $CAKLD$

$$= \frac{1}{1-1} = 1 + 1 + 1, \text{ \&c. } = \infty \times 1.$$

And likewise  $HAGLF = \frac{1}{1-1} = 1 +$

$1 + 1 + 1, \text{ \&c. } = \infty \times 1.$  From whence it appears that the Area of the Apollonian Hyperbola is infinite both ways.

Case 2. Let  $n=2$ ; so  $yx^2=1$  defines the next

Hyperbola in which  $CAKLD = \frac{1}{1-2} = 1 +$

$$2 + 4 + 8 + 16, \text{ \&c. } = \infty \times 2.$$

Case general. If you resolve  $\frac{1}{1-n}$  into a Series,

you will have  $CAKLD = \frac{1}{1-n} = 1 + n + n^2$

$+ n^3 + n^4 + n^5, \text{ \&c.}$  and because the Terms of this Series are in a geometrical Progression ascending

ending (supposing  $n < 1$ ) in the Ratio of 1 to  $n$ , therefore by *Prop. 2. §. 2.* the Sum thereof must be  $1 + n + n^2 + n^3 + n^4 + n^5, \text{ \&c.} = \infty \times \frac{n}{n-1}$

Now because  $n < 1$ , therefore  $\frac{n}{n-1}$  is  $< 1$ ;

therefore in all these Hyperbola's (in which  $n < 1$ ) the Area  $CAKLD$  will be an infinite Number of equal Parts, each of which (*viz.*

$\frac{n}{n-1}$ ) is greater than 1. And hence is understood

the meaning of the Geometers, who call these Spaces greater than infinite, that is greater than  $\infty \times 1$  or infinite in general.

*Corol. 2.* In all the Hyperbola's (except the *Apollonian*) the Infinite Area  $CAKLD$  (adjacent to the Asymptote  $AC$ ) is equal to an infinite Number of the finite Area  $HAGLF$  (adjacent to the Asymptote  $AH$ ) in the same Hyperbola.

*Demonstration.*  $CAKLD = \infty \times \frac{n}{n-1}$  by the

general Case, but  $HAGLF = \frac{n}{n-1}$  by *Corol.*

*1. § 6.* Therefore

$\{CAKLD = \infty \times HAGLF\}$  *Q. E. D.*

*Problem.* Let  $\infty \times e$  be the infinite Area  $CAKLD$  of any given Hyperbola, it is required to find another Hyperbola, whose infinite Space shall

shall be to the Space ( $\infty \times e$ ) of the given Hyperbola in any given Ratio, as of  $p$  to 1. *Sol.*

Let  $y x^n = 1$ . be the Equation of the Hyperbola sought, then by the general Case foregoing its

Area is  $= \infty \times \frac{n}{n-1}$ ; therefore by the condi-

tion of the Problem,  $\frac{n}{n-1} \cdot e :: p \cdot 1$ ; which

will give  $n = \frac{p e}{p e - 1}$ ; so that  $y x^{\frac{p e}{p e - 1}} = 1$

is the Equation to the Hyperbola sought; but  $p$  and  $e$  are given numbers, and therefore this is a known Equation, and consequently the Hyperbola defined by it is also known.

*Examp.* To find an Hyperbola whose Area shall be to that of the Apollonian, as 3 to 1. Now the Apollonian is  $= \infty \times 1$ , so  $e = 1$ , and  $p = 3$ . Ergo the Equation is  $y x^{\frac{3}{2}} = 1$ , whose Area by the general Case foregoing is  $= \infty \times 3$ , which is triple of the Apollonian.

*Prob. 2.* To find an Hyperbola, whose interminated Space  $H K L F$  shall be equal to any given number ( $a$ ) let  $y x^n = 1$  define the Hyperbola sought, where  $n < 1$ , then  $H A G L F =$

$\frac{n}{n-1}$  putting  $y = 1$  ( $= G L = G A.$ ) by *Corol.*

of § 6. and because  $A G L K = 1$ , therefore it will be  $H A G L F - A G L K (= H K L E) =$

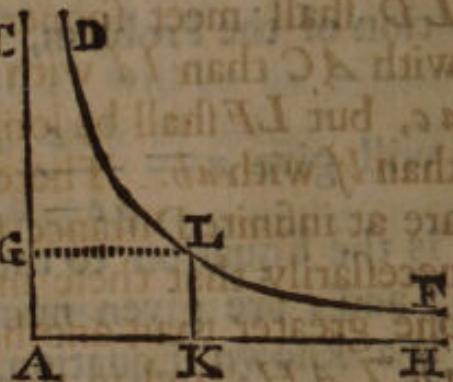
$\frac{n}{n-1} - 1$ . Therefore by the condition of the

*Prop.*

Problem  $\frac{n}{n-1} - 1 = a$ . which gives  $n = \frac{a+1}{a}$

so the Equation to the Hyperbola sought is  $\frac{a+1}{y x^a} = 1$ .

Let (as before)  $AC, C$   
 $AH$  be the Asymptotes  
of any Hyperbola  $DLF$   
defined by this Equati-  
on  $y x^n = 1$ , in which  
the Abscissa  $AK = x$ ,  
and Ordinate  $KL = y$ ,  
and  $n$  is suppos'd either



equal to, or greater than Unity. 1° It appears  
that in all Hyperbola's the interminate Space  
 $CAKLD$  is infinite, and the interminate Space  
 $HAGLF$  (except in the *Apollonian* where  $n = 1$ )  
is finite. 2° In every Hyperbola, one part of it  
continually approaches nearer and nearer to the  
Asymptote  $AC$ , and the other part continually  
nearer to the other Asymptote  $AH$ ; that is,  $LD$   
meets with  $AC$  at a Point infinitely distant from  
 $A$ , and  $LF$  meets with  $AH$  at a Point infinite-  
ly distant from  $A$ .

3°

(=)  $y = \frac{1}{x}$  increase as the Abscissa  $AK$  (=)

3°. In two different Hyperbola's  $DLF$ ,  $dlf$ , if we suppose  $n$  to be greater in the Equation of  $dlf$  than it is in the Equation of  $DLF$ , then  $LD$  shall meet sooner with  $AC$  than  $ld$  with



$ac$ , but  $LF$  shall be longer in meeting with  $AH$  than  $lf$  with  $ah$ . Therefore since these meetings are at infinite Distance from  $A$  and  $a$ , it follows necessarily that these infinite Distances must be one greater than another, viz.  $ac \angle AC$ , and  $ah \angle AH$ ; and in the same Hyperbola  $AC \angle AH$  and  $ac \angle ah$ , except the Apollonian in which  $AC = AH$ .

Therefore it must needs contribute very much to the right understanding the Scope of the foregoing Quadratures of these interminate hyperbolick Spaces, if we can determine the Length between the Centre  $A$  or  $a$  and the Point of concourse of either Part of the Hyperbola, with that Asymptote to which it approaches.

*Problem 3.* To find the Point  $C$  where  $LD$  meets with the Asymptote  $AC$ , and the Point  $H$  where  $LF$  meets with the Asymptote  $AH$ , for any Hyperbola  $DLF$ , whose Equation  $y x^n = 1$  is given.

*Solution.* It is evident that the Ordinates  $LK$  ( $= y = \frac{1}{x^n}$ ) increase as the Abscissa's  $AK$  ( $=$

$x$ )

$x$ ) decrease, so the last Ordinate must co-incide with the Asymptote  $AC$ , in which Case the Abscissa  $x = 0 = 1 - 1$ . Therefore  $AC = \frac{1}{1-1^n} = \frac{1}{x_n}$  Q. E. I.

*Examp. 1.* To find  $AC$  in the common Hyperbola  $y = \frac{1}{x}$ . Because in this  $n = 1$ , therefore  $AC = \frac{1}{1-1} =$  (by Art. 1. of § 5)  $1 + 1 + 1 + 1$ , &c.  $= \infty \times 1$ .

*Examp. 2.* To find  $AC$  in the Hyperbola whose Equation is  $y = \frac{1}{x^2}$ . Because in this  $n = 2$ , therefore from the general Solution  $AC = \frac{1}{1-1^2} = 1 + 2 + 3 + 4 + 5 + 6$ , &c.  $= \frac{\infty^2}{2}$ ; That is,  $AC$  is an infinite Number of equal Parts, each of which is  $\infty \frac{1}{2}$ : So that  $AC$  in this is an infinite Number of equal Parts, each of which is  $\frac{1}{2}$   $AC$  in the common Hyperbola

*Schol.* If we could give the Precise Sum of the Series in Art. 3, 4, &c. of Case 1. of § 5. we should then have  $AC$  for all the other Hyperbolas; but that is not easily to be done, as is declared in the Scholium at the End of § 5. Only

By this much we see (by *Case 4.* of § 5.) That  $AC$  increases as the Powers of  $\infty$  whose Exponents are  $n$ . So in the Hyperbola  $y = \frac{1}{x}$ ,  $AC$  is as  $\infty$ ; In the Hyperbola  $y = \frac{1}{x^2}$ ,  $AC$  is as  $\infty^2$ ; in the Hyperbola  $y = \frac{1}{x^3}$ ,  $AC$  is  $\infty^3$ ; and so on

*Part: 2d.* To find  $AH$  when  $LF$  meets with its Asymptote  $AH$ . Here we must consider  $GL$  ( $= x$ ) as the Ordinate, and  $AG$  ( $= y$ ) as the Abscissa. Now when  $GL$  becomes  $AH$ , then  $y = 0$ . But universally  $GL$  ( $= x$ )  $= \frac{1}{y^{\frac{1}{n}}}$

therefore  $AH = \frac{1}{0^{\frac{1}{n}}} = \frac{1}{1-1|^{\frac{1}{n}}}$ ; put  $\frac{1}{n} = e$ ,

and then by *Lem.* of § 5.  $AH = \frac{1}{1-1|} e = 1 +$

$$e + \frac{e \times e + 1}{2} + \frac{e \times e + 1 \times e + 2}{2 \times 3} + \frac{e \times e + 1 \times e + 2 \times e + 3}{2 \times 3 \times 4}, \&c.$$

But since we cannot assign the Sum of these Progressions, therefore this Series is of no use in the Solution of the Problem. We shall therefore consider the Problem (as to the finding  $AH$ ) under two Cases, first when  $n$  is an Integer, and secondly when it is a Fraction.

*Case*

*Case 1.* When  $n$  is an Integer. So if  $n = 1$  (as in the common Hyperbola) then  $AH (= \frac{1}{1-1}) = 1 + 1 + 1, \&c. = \infty \times 1 = AC$ . If  $n = 2$ , then  $AH (= \frac{1}{1-1} = \sqrt{\frac{1}{1-1}} = \sqrt{\infty \times 1})$  is a mean Proportional between 1 and Infinite.

If  $n = 3$ , then  $AH (= \frac{1}{1-1} = \sqrt[3]{\frac{1}{1-1}} = \sqrt[3]{\infty \times 1})$  is the first of two mean Proportionals between 1 and Infinite. And universally if between 1 and Infinite there be supposed as many mean Proportionals as there are Units in  $n - 1$ ,

then  $AH (= \frac{1}{1-1} = \sqrt[n]{\frac{1}{1-1}} = \sqrt[n]{\infty \times 1})$  shall be the first of these Means.

*Case 2d.* When  $n$  is a Fraction, suppose  $n = \frac{p}{q}$ , but  $p < q$ , because we always suppose  $n < 1$  except in the *Apollonian* where  $n = 1$ . So then

$\frac{1}{n} = \frac{q}{p}$ , therefore  $AH = \frac{1}{1-1} = \sqrt[\frac{p}{q}]{\frac{1}{1-1}^q} = \sqrt[\frac{p}{q}]{\infty \times 1} = \sqrt[\frac{p}{q}]{\infty \times 1^q}$ . So for ex. if  $n = \frac{2}{3}$

*viz.*  $p = 3, q = 2$ , then  $AH = \sqrt[3]{\frac{1}{1-1}^2} = \sqrt[3]{\infty \times 1^2}$

Corol.



Number of equal Parts, each of which is  $\frac{1}{\sqrt{\infty}}$  or 1 divided by the mean between 1 and  $\infty \times 1$ .

So that this equal part  $\frac{1}{\sqrt{\infty \times 1}}$  is neither finite, nor infinitely small, nor infinitely great, and consequently the mean  $\sqrt{\infty \times 1}$  is not properly an infinite Number. And hence we see that there are Progressions of Numbers whose Sums are neither finite nor infinite, but between both.

*Ex. gra.*  $\sqrt{\infty \times 1}$  where  $p = 2, q = 1$ , so  $\sqrt{\infty \times 1} = \frac{1}{1-1} = 1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} \&c.$  is a Num-

ber neither finite nor infinite: and so all the means between 1 and Infinite, are neither finite nor infinite.

I have hitherto considered only these Cases in which  $n =$  or  $<$  1; let us now see what would be the Result if we suppose  $n = 0$ . It is evident then that the general Equation, *viz.*  $yx^n = 1$  to all Hyperbola's would, in, this Case be  $y = 1$ , so that the Hyperbola's will in this Case degenerate into a strait Line  $DLF$ , parallel to  $AH$ . But considering it as the simplest Hyperbola, let us consider at what distance it will meet with its Asymp-



totes. Now universally  $AC = \frac{1}{x^n}$  (by the Sol when

of part. 1. of *Prob. 3.*) when  $x = 0$ , but  $n = 0$  by Supposition: Ergo, be  $x$ , what it will  $x^0 = 1$ , Ergo,  $AC = 1$ ,  $2^0$ . From the Solution of part 2. of *Prob. 3.* we have found that  $AH =$

$$\frac{1}{1-1} \cdot \frac{1}{1-1}^n$$

which in this Case will give  $AH =$

$$\frac{1}{1-1} \cdot \frac{1}{1-1} = \frac{1}{1-1} \cdot \frac{1}{1-1}, \text{ that is } AH = \infty \cdot \infty \text{ or}$$

the infinite Power of infinite.

*Corol. 1.* Considering a strait Line as an Hyperbola, it can have but one Asymptote, *viz.*  $AH$ , whose Concurse with  $AH$  is at greater Distance from  $A$  than any other Hyperbola whatsoever.

*Corol. 2.* All the Hyperbola's  $y x^n = 1$  whose Asymptotes are  $AC$ ,  $AH$  must intersect  $DF$ , and the greater  $n$  is, so much the more they bend towards  $AH$  and recede from  $DF$ . And as they all intersect  $DF$ , so they all intersect one another in one point only; and after the Intersection, that in which  $n$  is greatest, still falls lowest or approaches nearest to  $AH$ .

*Schol.* If you suppose  $n$  infinitely great, *viz.*

$$n = \frac{1}{1-1},$$

then the Hyperbola will be a strait

Line parallel to the Asymptote  $AC$ .

*Sect. 7.* We have now finished this Business of the Hyperbola's which has afforded us a new Speculation of Numbers, *viz.* of such as are

M

neither

neither finite nor infinite, which deserves to be consider'd better than either my Time or my Capacity will permit. However I shall here set down a few thoughts about them, till I have more Leisure to prosecute them.

First then, to distinguish them from finite and infinite, I shall call them *indefinite* Numbers, and denote them by this Sign  $\alpha$ .

2<sup>o</sup>. *Indefinite* Numbers I suppose to be intermediate Numbers lying between finite and infinite: For as we do not descend from 1 to 0 at one Step, but must pass through an infinite Series of Fractions,  $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, &c.$  So it is impossible that in ascending from 1 to  $\infty$ , we should pass immediately from finite to infinite; therefore the Steps between these two are *indefinite* Numbers: thus before we arrive from 1 to  $\infty$  1, we must come at  $\sqrt{\infty}$  1, and before we come at  $\sqrt{\infty} \times 1$  we must first come at  $\sqrt[3]{\infty} \times 1$  and so on.

3<sup>o</sup>. The Rules for the Arithmetick of *Indefinites*, may be made after the same manner as is done for that of *Infinites* by D. Cheyne. To

which I shall add, that an *Indefinite* as  $\infty \frac{q}{p}$  or  $\sqrt[p]{\infty} \frac{q}{p}$  multiplied by another *Indefinite* as  $\infty \frac{r}{s}$

makes the Product  $\infty \frac{q}{p} \frac{r}{s}$  this Product becomes

comes Infinite when it happens that  $qs + pr <$  or  $= ps$ , but the Product is only Indefinite when  $qs + pr > ps$ . And if an Indefinite as  $\infty | \frac{q}{p}$

be divided by another Indefinite as  $\infty | \frac{r}{s}$ , the

Quotient  $\infty | \frac{p}{q} - \frac{r}{s}$  is infinite when  $qs - pr$  is  $<$  or  $= ps$ ; but it is finite when  $qs - pr = 0$ , and indefinite when  $qs - pr > ps$ .

*Note*, That in expressing an Indefinite Number by  $\infty | \frac{p}{q}$ , I always suppose the Numerator

$q$  less than the Denominator  $p$ ; for if  $q$  be either  $<$  or  $= p$ , then  $\infty | \frac{p}{q}$  is an Infinite. That these Numbers are not infinite, may be thus demonstrated. If (*ex. gr.*)  $\sqrt{\infty \times 1}$  were infinite, then

$\infty \times \frac{1}{\sqrt{\infty}}$  ( $= \sqrt{\infty \times 1}$ ) must be infinite, and

also  $\frac{1}{\sqrt{\infty}}$  must be  $= 0$ ; *Ergo*  $\infty \times 0 = \infty \times$

$\frac{1}{\sqrt{\infty}}$  ( $= \sqrt{\infty}$ ) = infinite, but  $\infty \times 0 = 1$ ;

*Ergo*  $1 =$  infinite, which is absurd.

*Sect.* 8. Containing some miscellaneous things relating to Infinites.

*Lem.* Let  $FBDde$  be a Logarithmick Curve whose first Ordinate  $AB = 1$ , Abscissa  $AC = x$ , Ordinate  $CD = y$ , and Asymptote  $Ee$ :

Now from the known Property of this Curve, it Follows,

1°. That  $AC$  are the Logarithms of  $CD$ , *i. e.* If you make the Ordinate  $y = CD$  represent a Number, then its Abscissa  $x (= AC)$  shall be the Logarithm thereof.

2°. That the Logarithm of 1 is nothing; for the first Ordinate  $AB = 1$ , but its Abscissa is  $= 0$ , therefore (by 1°) the Log. of  $1 = 0$ .

3°. That the Ordinates  $cd$  (to the left of  $AB$ ) denoting Fractions, their respective Abscissa's  $Ac$  are the Logarithms of these Fractions: So that as  $x$  is the Log. of any Integer,  $CD$ , in the like manner  $-x$  denotes the Log. of any Fraction ( $cd$ ).

4°. That the Log. of any Fraction  $\frac{1}{n}$  is equal to  $-$  Log. of  $n$ . So that the Log. of any Fraction (whose Numerator is 1) is equal in Magnitude to the Log. of that whole Number, which is the Denominator; there being no Difference between the Log. of that Fraction  $\frac{1}{n}$  and the Log. of this Integer  $n$ , but that this is  $+x$  (because it lies to the right from  $A$  towards  $E$ )

$E$ ) and the other  $-x$  because it lies to the left from  $A$  towards  $e$ .

*Demonstration.*  $\frac{1}{n}$  signifies 1 divided by  $n$ , therefore by the Rules of Division  $l : 1 - l : n = \text{Log. of the Quotient, viz. } l : \frac{1}{n}$ . But  $l : 1 = 0$  (by 2<sup>o</sup>) Ergo  $-l : n = l : \frac{1}{n}$ . Q. E. D.

5<sup>o</sup>. If this Curve be continued (*utrinque*) from  $B$  in *infinitum*, then  $f$ , will meet with the Asymptote at an infinite Distance  $Ae$ : But it will diverge from the Asymptote on the other side, so that at an infinite Distance  $AE$  the last Ordinate  $EF$  will be infinite. And since the last Ordinate  $ef$  is  $= 0$ , whose Abscissa  $Ae = \infty$ , it is evident that the Log. of 0 is  $= \infty$  or rather  $= -\infty$ : It is evident likewise the last Ordinate  $EF$  is  $= \infty$ , whose Abscissa  $AE$  is also  $= \infty$ . So that the Log. of 0 and the Log. of  $\infty$  are equal, only the one is  $+\infty$  and the other  $-\infty$ .

*Prop. I.*  $\frac{1}{0} = \infty = 1 + 1 + 1 + 1 + 1, \text{ \&c.}$

This may seem absurd, but the Demonstration is evident from the foregoing Lemma. For  $\frac{1}{1-1}$

$\frac{1}{0} = \frac{1}{1-1}$ . Let then  $\frac{1}{1-1} = y$ . That is  $1-1 = \frac{1}{y}$ .

This reduc'd to a logarithmical Equation gives  
 $-1 \times l : \frac{1}{1-1} = l : y$ ; that is  $-1 \times l : 0 = l : y$ .  
 But  $l : 0 = -\infty$  (by *Art. 5.* of the *Lem.*) Ergo  
 $-1 \times -\infty l : y$ , that is  $+\infty = l : y$ . There-  
 fore  $y$  is infinite (*sc.*  $y = \infty$ ) for no Number has  
 an affirmative and infinite Logarithm, except  
 an infinite Number. Since then  $y = \infty$ , then

$$\frac{1}{1-1} = \infty \text{ that is } \frac{1}{0} = \infty. \text{ Q. E. D.}$$

*Schol.* But by 0 cannot be understood absolute nothing, for an infinite Number of absolute Nothings cannot make 1: but by 0 is understood an infinitely small part, as in the *calc. diff.*  $dx$  is an infinitely small part of  $x$ , so that  $dx$  is as 0 to  $x$ : not that  $dx$  is absolutely nothing, for it is divisible into an infinite Number of Parts, each of which is  $ddx$ . And therefore the Demonstration, which supposing  $f$  and  $e$  meeting at an infinite Distance  $Ae$ , makes the last Ordinate  $ef = 0$ , implies no more but that  $ef = dx$ . But then it may be inquir'd what is the Quotient that arises from the Division of 1 by absolute Nothing. I say there is no Quotient because there is no Division: therefore it is a Mistake to say the Quotient is 1 or Unity undivided, which is demonstrably false, neither is the Quotient  $= 0$ . For properly speaking there is no Quotient, and therefore it is an Error to assign any. In like manner, it is an Error to say that  $0 \times a$  makes the Product 0; for properly speaking there



Logarithm of any affirmative Fraction,  $Ae$  the  
 Logarithm of an infinitely little Fraction  $fc$   
 $= dx$ .  $AzA$ ,  $AzE$ , &c. The Logarithms  
 of the negative Numbers,  $zAzB$ ,  $zEzF$ , &c.

Now let  $n$  be any Number greater than Uni-  
 ty, then  $1-n$  will be a negative Number, let

us now see what the Quotient of  $\frac{1}{1-n}$  will be,

let it be  $y$ , so  $\frac{1}{1-n} = y$  i.e.  $\overline{1-n}^{-1} = y$ , this re-

duc'd to a logarithmick Equation, Equation  
 gives  $-1 \times l : 1-n = l : y$ .

But  $1-n$  is a negative Number, suppose (ex.  
 gr.) of  $zAzB$  then  $AzA$  is  $=l : 1-n$ , there-  
 fore  $-1 \times AzA = l : y$ . but  $AzA \angle Ae$ , and  
 $Ae = -\infty$ , therefore  $AzA \angle -\infty$ . Let  
 then  $AzA = -\infty \times a$  (where  $a \angle 1$ ) then  $-1$   
 $\times -\infty a = l : y$ , that is  $\infty \times a = l : y$ , but  $\infty \times$   
 $a \angle \infty$ , Ergo  $y$  is a Number greater than infi-  
 nite.

And here it is observable that there are affir-  
 mative Numbers less than nothing, denoted by  
 the several Powers of  $dx$ , as  $dx^2$ ,  $dx^3$ , &c. or  
 by the second, third, &c. Differences, and these  
 Numbers may be aptly represented by the Ordi-  
 nates of the Logarithmick Curve, continued  
 from  $f$  towards  $zH$  when  $dx^n$  is affirmative, or  
 from  $z f$  towards  $H$  when  $dx^n$  is negative.

Another way of explaining what is meant by

$$\frac{1}{0} = \infty.$$

Let

Let  $AA$  produced indefinitely be divided into equal Parts  $AB, BC, CD, DE, \&c.$  so that a Part of this Line shall denote any Number, supposing  $AB = 1$ , let then  $x$  denote any Number,

ex. gr. let  $x = AB$  and  $y = Ab$ . so  $\frac{1}{y-x} = \frac{1}{y} + \frac{x}{y^2} + \frac{x^2}{y^3} + \frac{x^3}{y^4} + \frac{x^4}{y^5}, \&c.$

Now suppose  $b$  infinitely near to  $B$ , then  $y-x = Bb = dx$ , so that  $\frac{1}{y-x} = \frac{1}{dx}$ . But  $x = dx + dx + dx, \&c.$  That is  $1 \times x = dx \times 1 + 1 + 1 + 1, \&c.$  And therefore  $\frac{1}{dx} = \frac{1}{x} + \frac{1}{x} + \frac{1}{x} + \frac{1}{x}, \&c.$  But by Supposition  $x = AB$

$= 1$ . Ergo  $\frac{1}{dx} = 1 + 1 + 1 + 1, \&c. = \infty \times 1$

But  $\frac{1}{0} = 1 + 1 + 1 + 1, \&c.$  Ergo  $\frac{1}{0} = \frac{1}{dx}$ , or  $dx = 0$ , but  $dx$  is not absolute nothing, and therefore when we say  $\frac{1}{0} = 1 + 1 + 1, \&c.$

$0$  does not denote absolute nothing, but only  $dx$  or an infinitely small part of  $x$ . And therefore  $\infty = \text{fore}$

fore when (in the Quotient  $\frac{y}{x}$ ) we say let  $y = x$ , the meaning is not that  $y$  is absolutely equal to  $x$ , (for then there would be no Division, and consequently no Quotient) but only that  $y$  exceeds  $x$  by an infinitely small Quantity  $dx$ , which is sufficient to make them equal.

I have hitherto considered no Progressions of Numbers except these that are in Arithmetical and Geometrical Progressions, and these that

arise from  $\frac{1}{1-r}$   $e$  as in § 5. I shall now proceed

to treat of other Progressions, and these which offer themselves first are the several powers of Numbers in an Arithmetical Progression. Let then  $z$  denote the Sum of any Arithmetical Progression  $a, a+x, a+2x, a+3x, a+4x, \&c.$   $A$  the Sum of their Squares,  $B$  the Sum of their Cubes,  $C$  the Sum of their Biquadrates,  $\&c.$  that is, let

$$z = a + (a+x) + (a+2x) + (a+3x) + (a+4x) \&c.$$

$$A = a^2 + (a+x)^2 + (a+2x)^2 + (a+3x)^2 + (a+4x)^2 \&c.$$

$$B = a^3 + (a+x)^3 + (a+2x)^3 + (a+3x)^3 + (a+4x)^3 \&c.$$

$$C = a^4 + (a+x)^4 + (a+2x)^4 + (a+3x)^4 + (a+4x)^4 \&c.$$

And

And so on to higher Powers. Now in order to find the Sum of any of these Progressions ascending till the last Term is  $= \infty \times 1$ , I shall premise these following *Lemma's*, by the help whereof you may find  $z, A, B, C, \&c.$  for any number of Terms. Calling therefore  $t$  the number of Terms in each Series, and  $v$  the last Term of the first whose Sum is  $z$ . I say

$$\text{Lem. 1. } z = \frac{v^2 + xv + ax - a^2}{2x}$$

$$\text{Lem. 2. } A = \frac{v + x|^3 - a^3 - tx^3 - 3x^2 z}{3x}$$

$$\text{Lem. 3. } B = \frac{v + x|^4 - a^4 - tx^4 - 4x^3 z}{4x}$$

$$6x^2 A - 10x^3 B = \frac{v + x|^5 - a^5 - tx^5 - 5x^4 z}{5x}$$

$$10x^3 A - 10x^2 B$$

In each of which  $tx = v + x - a$  (by *Lem. 1.*  $\S$  1.) and it is easy to continue these *Lemma's* for higher Powers.

Before we apply these *Lemma's* to the finding the Sum of any Progression whose last Term is infinite, it will be necessary to substitute the values of  $t, z, A, B, C, \&c.$  When you have made this Substitution, you must reject out of the *Lemma's* every Term in which  $v$  does not occur; for the last Term being infinite, will make  $v$  an indefinite Number, and since all the other

other Terms (in which  $v$  is not) are finite, therefore they are as nothing in respect of  $v$  and consequently to be rejected. So, for Progressions whose last Term is  $= \infty$ , the *Lemma's* will be

$$\text{Lem. 1. } z = \frac{v^2 + xv}{2x}$$

$$\text{Lem. 2. } A = \frac{v^3 - x^2v}{3x} - \frac{v^2 - xv}{2x}$$

$$\text{Lem. 3. } B = \frac{v^4 - 2xv^3 + x^2v^2 + 2x^3v}{4x}$$

$$\text{Lem. 4. } C = \frac{v^5 - 15v^4 + 10xv^3 - 59x^3v}{5x}$$

Let us now consider what the value of  $v$  is, in each of the *Lemma's*  $A, B, C, \&c.$  An example or two will make the thing plain.

*Ex. 1.* Let  $\left\{ \begin{array}{l} 1, 2, 3, 4, 5, \&c. \text{ to } v, \text{ whose} \\ \text{Sum is } z. \end{array} \right.$

Then for *Lem. 2.*  $\left\{ \begin{array}{l} 1, 4, 9, 16, 25, \&c. \text{ to } v^2, \\ \text{whose Sum is } A. \end{array} \right.$

But  $v^2 = \infty$  (by *Supp.*) Therefore  $v = \sqrt{\infty} = \infty^{\frac{1}{2}}$  so that  $\infty^{\frac{1}{2}}$  is the value of  $v$  in *Lem. 2d.* In like

manner  $\sqrt[3]{\infty}$  or  $\infty^{\frac{1}{3}}$  is the value of  $v$  in *Lem. 3.*

And universally if  $e$  denote the Exponent of the Power to which each of the Terms of any Arithmetical Progression are raised, then  $v =$

$\sqrt[e]{\infty} = \infty^{\frac{1}{e}}$ . in the *Lemma* that gives the Sum of these Terms (whose last is  $\infty$ ) raised to this Power.

*Prop.*

*Prop. 1.* To find the Sum of a Series of Numbers (continued till the last Term is  $\infty$ ) whose Terms are the Squares of any Arithmetical Progression.

By *Lem. 2.* the Sum sought is  $A = \frac{v^3 - x^2v}{3x}$

$\frac{v^2 - xv}{2}$ , but in this Case  $v = \sqrt{\infty}$  or  $\infty^{\frac{1}{2}}$ ,

therefore all the Terms except the highest must evanish, and consequently the Sum of the

Squares  $A = \frac{v^3}{3x} = \frac{\infty^{\frac{1}{2} \cdot 3}}{3x} = \frac{\infty^{\frac{3}{2}}}{3x} = \infty \times \frac{\infty^{\frac{1}{2}}}{3x}$ ,

*Examp.* Let  $x$  be  $= 1$ , so  $1, 2, 3, 4, \&c.$  to  $\sqrt{\infty}$  is the Arithmetical Progression, the Sum ( $A$ ) of whose Squares is sought; I say  $1 + 4 + 9 + 16 \&c. \infty \times \frac{1}{3} \sqrt{\infty}$  that is, the Sum of the Progression is an infinite Number of equal Parts, each of which is  $\frac{1}{3} \sqrt{\infty}$ .

*Prop. 2.* To find the Sum of the Cubes of any Arithmetical Progression.

In this Case  $v = \sqrt[3]{\infty}$  or  $\infty^{\frac{1}{3}}$ . Therefore in *Lem. 3d.* all the Terms except the highest must

evanish, so that  $B = \frac{v^4}{4x} = \frac{\infty^{\frac{1}{3} \cdot 4}}{4x} = \frac{\infty^{\frac{4}{3}}}{4x}$

$= \infty \times \frac{\infty^{\frac{1}{3}}}{4x}$ .

*En.*

*Ex.* Let  $x = 1$ , so 1, 2, 3, 4, 5, &c. to  $\sqrt[3]{\infty}$  is the Arithmetical Progression, the Sum ( $B$ ) of whose Cubes is sought, I say  $1 + 8 + 27 + 64 + 125$  &c.  $= \infty \times \frac{\infty^{\frac{1}{3}}}{3}$ .

*Prop. 3.* To find the Sum of the Biquadrates of any Arithmetical Progression.

In this Case  $v = \sqrt[4]{\infty}$  or  $\infty^{\frac{1}{4}}$ . Therefore by *Lemma 3d.*  $C = \frac{1}{5^x} = \frac{1}{5^x \infty^{\frac{1}{4}}} = \frac{1}{5^x \infty^{\frac{1}{4}}}$   
 $= \infty \times \frac{\infty^{\frac{1}{4}}}{5^x}$ .

*Ex.* Let  $x = 1$ , so 1, 2, 3, 4, &c. to  $\sqrt[4]{\infty}$  is the Arithmetical Progression, I say then that  $1 + 16 + 81 + 256$  &c.  $= \infty \times \frac{\infty^{\frac{1}{4}}}{5}$ .

*Prop. 4. Universal.* Let  $e$  denote the Exponent of any Power, to which the Terms of any Arithmetical Progression  $a + x$ ,  $a + 2x$ ,  $a + 3x$ , &c. are raised, and it is required to find the Sum of the Terms so raised. I say

$a^e + a^e + x^e + a^e + 2x^e + a^e + 3x^e + a^e + 4x^e$   
 &c.  $= \infty \times \frac{\infty^{\frac{1}{e}}}{e+1 \times x}$ .

*Scholium.* From hence may be easily deduc'd the Quadratures of all the Parabola's  $z = y^e$  (where

where  $z$  is the Ordinate,  $y$  the Abscissa, and  $e$  an affirmative Number) which is one remarkable use of this Arithmetick of Infinites. For if in this Figure  $AB = y$ ,  $BC = z$ , and  $z = y^e$  it is plain that if you put  $y = 1, 2, 3, 4, 5, \&c.$  successively, then will  $z = 1^e, 2^e, 3^e, 4^e, \&c.$  successively: which shews that the Ordinates are the Terms of



an Arithmetical Progression rais'd to a Power, whose Exponent is  $e$ , and that  $(x)$  the common Difference is 1; But if the first Abscissa  $y = 1$  be infinitely (or indefinitely small) then the Ordinates will be infinitely near to one another, and the last Ordinate  $BC$  will be an  $\infty$  Number of these Ones. Therefore since to find the Area  $ABC$ , is, in effect, to find the Sum of the Ordinates, and since the Ordinates are  $1^e, 2^e, 3^e, 4^e, 5^e, \&c.$  till you come to the last which is  $BC = \infty$ . Therefore by Prop. 4.  $ABC = \infty \times$

$$\frac{\infty^{\frac{1}{e}}}{e+1}, \text{ that is } ABC = BC \times \frac{1}{e+1}, \text{ the same}$$

which is found by the ordinary Methods of Quadratures. And note that the whole Abscissa  $AB$  denotes the Number of the Terms.

N. B. *The Quadrature of all sorts of Curves, express'd by one Term thus assign'd, it is easy by the Method of Assumptions of Series's to extend this Method to all Sorts of Quadratures hitherto discovered.*

(where)

## ADDITIONS.

I have shewn in p. 160. &c. that mean Proportio-  
nals, between 1 and  $\infty$  are neither finite nor infi-  
nite. For a farther illustration of what I have said  
upon this Head let us consider what these Progre-  
ssions are, whose Sum is more than finite and  
less than infinite.

*Prop. 1.*  $\sqrt{\infty}$  is a mean between 1 and infi-  
nite; but  $\infty = \frac{1}{1-1}$ , therefore  $\sqrt{\infty} =$

$\frac{1}{\sqrt{1-1}} = \frac{1}{1-1}^{\frac{1}{2}}$  which by Sir Isaac Newton's The-  
orem gives

$$\begin{aligned} \sqrt{\infty} &= \frac{1}{1-1}^{-\frac{1}{2}} = 1 + \frac{1}{2} + \frac{1 \times 3}{2 \times 4} + \frac{1 \times 3 \times 5}{2 \times 4 \times 6} \\ &+ \frac{1 \times 3 \times 5 \times 7}{2 \times 4 \times 6 \times 8}, \text{ \&c. that is } \sqrt{1+1+1}, \text{ \&c.} \\ &= 1 + \frac{1}{2} + \frac{1 \times 3}{2 \times 4} + \frac{1 \times 3 \times 5}{2 \times 4 \times 6} + \frac{1 \times 3 \times 5 \times 7}{2 \times 4 \times 6 \times 8}, \text{ \&c.} \end{aligned}$$

And so (by squaring each side of this Equati-  
on) you will find it in Fact to be  $1 + 1 + 1$ ,  
&c.  $= 1 + 1 + 1$ , &c. From hence it appears  
that the Progression, whose Sum (being neither  
finite nor infinite) is  $\sqrt{\infty}$  consists of Fractions  
whose Numerators are the Products of the con-  
tinual Multiplication of the Arithmetical Pro-  
gression

gression 1, 1, 3, 5, 7, 9, &c. and the Denominators are the Products of the Multiplications of the Terms of this Arithmetical Progression 2, 4, 6, 8, 10 &c.

*Corol.* In like manner you may find  $\sqrt[3]{\infty}$  &c. by resolving  $\frac{1}{\sqrt[3]{1-1}}$  =  $\frac{1}{1-1}$   $^{-\frac{1}{3}}$

$\frac{1}{\sqrt[3]{1-1}}$  =  $\frac{1}{1-1}$   $^{-\frac{1}{3}}$  &c. into a Series by

Sir Isaac Newton's Theorems. So

$$\sqrt[3]{\infty} = \frac{1}{\sqrt[3]{1-1}} = \frac{1}{1-1}^{-\frac{1}{3}} = 1 + \frac{1}{3} + \frac{1 \times 4}{3 \times 6}$$

$$+ \frac{1 \times 4 \times 7}{3 \times 6 \times 9} \text{ \&c. where the Numerators and}$$

Denominators are in Arithmetical Progressions, whose common difference is 3.

$$\sqrt[5]{\infty} = \frac{1}{\sqrt[5]{1-1}} = \frac{1}{1-1}^{-\frac{1}{5}} = 1 + \frac{1}{5} + \frac{1 \times 6}{5 \times 10}$$

$$+ \frac{1 \times 6 \times 11}{5 \times 10 \times 15} \text{ \&c. } \sqrt[7]{\infty} = \frac{1}{\sqrt[7]{1-1}} = \frac{1}{1-1}^{-\frac{1}{7}}$$

$$\frac{1}{7} = 1 + \frac{1}{e} + \frac{1 \times e + 1}{e \times 2e} + \frac{1 \times e + 1 \times 2e + 1}{e \times 2e \times 3e}$$

$$+ \frac{1 \times e + 1 \times 2e + 1 \times 3e + 1}{e \times 2e \times 3e \times 4e} + \frac{1 \times e + 1 \times 2e + 1}{e \times 2e \times 3e}$$

$$+ \frac{1 \times 3e + 1 \times 4e + 1}{e \times 4e \times 5e} \text{ \&c.}$$

*Prop. 2.* Let 1 be the first,  $r$  the second, and  $v$  the last Term of a Geometrical Progression  $1, r, r^2, r^3, r^4, \&c.$  and  $t$  the number of Terms, then  $v = r^{t-1} = \frac{r^t}{r}$ , which gives  $r^t = r v$ .

*Corol.* Let  $\tau$  be the number of Terms, and  $v$  the last Term in the like Progression  $1, s, s^2, s^3, s^4 \&c.$  then  $v = s^{\tau-1}$ .

*Corol. 2.* From these two Values of  $v$ , I have this Equation  $r^{t-1} = s^{\tau-1}$ ; whence it appears that if  $s$  be greater than  $r$ , then will  $\tau < t$ , that is, In any two Progressions whose first Terms are the same, that whose second Term  $s$  is greater than  $r$  the second Term of the other, will sooner arrive at any given number  $v$ .

*Example.* Let  $r = 2$ , then  $1, 2, 4, 8, 16$ . Let  $s = 4$ , then  $1, 4, 16$ . that is, there are 5 Terms (or  $t = 5$ ) in arriving at 16 in the first Progression, whereas in the second ( $\tau = 3$ ) it arrives at 16 in the 3<sup>d</sup> Term.

*Problem* Having  $r, t, s$ , to find  $\tau$  in which they shall both have the same last Term  $v$ .

*Sol.*  $s^{\tau-1} = r^{t-1}$  (by *Corol. 2.*) this turn'd into a logarithmical Equation is  $\tau - 1 \times l s = t - 1 \times l r$ , which reduced gives  $\tau = \frac{t l r + l s - l r}{l s} =$

$$\frac{t l r - l r}{l s} + 1. \quad \text{Q. E. I.}$$

*Corol.* Because by *Prop. 2.*  $r^t = r v$ , therefore  $t l r = l r v$ , so substituting  $l r v$  in place of

of  $tlr$ , we shall have  $\tau = \frac{lrv - lr + ls}{ls} =$

$$\frac{lrv}{ls} - \frac{lr}{ls} + 1.$$

*Corol. 2.* Because by *Corol. 1.*  $tlr = lrv$ , therefore  $t = \frac{lrv}{lr}$ . And consequently

$$t - \tau = \frac{lrv}{lr} - \frac{lrv}{ls} + \frac{lr}{ls} - 1.$$

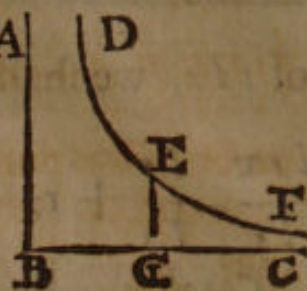
But by the known property of Numbers we have  $lr + lv = lrv$ , therefore  $t - \tau = \frac{lr + lv}{lr} - \frac{lr + lv}{ls} + \frac{lr}{ls} - 1$  that is  $t - \tau = 1 + \frac{lv}{lr} - \frac{lv}{ls} - 1$ , that is,

$$t - \tau = \frac{lv}{lr} - \frac{lv}{ls}.$$

*Corol. 3.* Let the last Term  $v$  be infinite or  $\infty$ , then  $t - \tau = \frac{l:\infty}{lr} - \frac{l:\infty}{ls}$ ; which shews

how much sooner the Progression  $1, s, s^2, s^3, \&c.$  will arrive at  $\infty$ , than  $1, r, r^2, r^3, \&c.$  that is, how many more Terms there is in  $1, r, r^2, r^3, \&c.$  than in  $1, s, s^2, s^3, \&c.$  when the last in both is  $\infty$ .

Prop. 3. Let  $BG = x$   $GE$   $A$   
 $= y$ ;  $yx^s = 1$ , where  $s$  is any  
 number greater than Unity.  
 Then by the *Calculus Integra-*  
*lis*, we have  $DEGBA =$   
 $\frac{x^{1-s}}{1-s}$ , so putting  $x = 1$ , we have  $DEGBA =$   
 $\frac{1}{1-s}$ .



But  $\frac{1}{1-s} = 1 + s + s^2 + s^3 + s^4 \&c. =$   
 $DEGBA$ .

But calling  $v$  the last Term of this ascending  
 Geometrical Progression  $1 + s + s^2 + s^3 + \&c.$   
 we shall (as is shewn in Page 136. of this Chapter)  
 have  $1 + s + s^2 + s^3 + s^4 + \&c. = \frac{s v}{s - 1}$ , there-

fore  $DEGBA = \frac{s v}{s - 1}$ . So that we have three  
 different expressions of the Area  $DEGBA$ , viz.

$\frac{1}{1-s}$ ,  $\frac{s v}{s - 1}$ , and the Series  $1 + s + s^2 + s^3 +$   
 $s^4 \&c.$

But what this number  $v$  is (which denotes the  
 last Term of the Progression  $1 + s + s^2 + s^3 \&c.$ )  
 is not so easy to determine; certainly it cannot  
 be  $v = \infty \times 1$  or  $1 + 1 + 1 \&c.$  For then  
**DEGBA**

$DEGBA = \infty \times \frac{s}{s-1}$ ; therefore if in one Hyperbola we put  $s = 2$ , (*scil.*  $yx^2 = 1$ ) we have  $DEGBA = \infty \times 2$ ; and putting in another  $s = 3$  (*scil.*  $yx^3 = 1$ ) we have  $DGEB A = \infty \times \frac{1}{2}$ ; now this would make the Area of the Hyperbola  $yx^2 = 1$  *scil.*  $\infty \times 2$  greater than the Area of the Hyperbola  $yx^3 = 1$  *scil.*  $\infty \times \frac{1}{2}$  (because  $2 < \frac{1}{2}$ ) but it is easy to Demonstrate, that in the Hyperbola's  $yx^s = 1$ , the greater we suppose the Exponent  $s$ , so shall the Area  $DEGBA$  (adjacent to  $BG$ ) be the greater, and consequently the last Term  $v$  of the series  $1 + s + s^2 + s^3 \&c.$  cannot be  $\infty$  or  $1 + 1 + 1 + 1 \&c.$  for upon that value of  $v$ , the expression  $\frac{s v}{s-1}$  would make the Area

$DEGBA$  to decrease as  $s$  did increase.

To discover the value of  $v$ , we have  $DGEB A = \frac{s v}{s-1} = \frac{1}{1-s}$ ; which gives  $v = \frac{s-1}{s-s} = \frac{s-1}{s}$   
 $\times \frac{1}{1-s} = \frac{1}{-s}$ .

Having found  $v = \frac{1}{-s}$ , we see that in two different Hyperbola's (*Ex gr*  $yx^2 = 1$ , and  $yx^3 = 1$ .)  $v$  cannot have the same value, for in the former  $v = \frac{1}{-2}$ , which is less than  $v = \frac{1}{-3}$  in the other.

Secondly. From the value of  $v = \frac{s-1}{s} \times \frac{1}{1-s}$  we see that the last Term  $v$  is equal to the Sum of the Series (*viz.*  $1 + s + s^2 + s^3 \&c$ ) multiplied upon  $\frac{s-1}{s}$  for  $\frac{1}{1-s}$  is  $= 1 + s + s^2 + s^3 \&c$ .

Corol. I say the last Term  $v$  cannot be  $\infty \times n$ , take what number you will for  $n$  (except in the Case of the common Hyperbola, where  $s = 1$ ) For if it were possible, let  $v = \infty \times n$ ; then must  $\frac{s-1}{s-s^2} = \infty \times n$ , therefore  $s-1 = \infty \times ns - ns^2$ , which gives  $1 = \infty \times \frac{ns - ns^2}{s-1}$ , and consequently

$\frac{1}{\infty} = \frac{ns - ns^2}{s-1}$ , but  $\frac{1}{\infty} = 0$ , therefore  $\frac{ns - ns^2}{s-1} = 0$ , which gives  $s = 1$ . Q. E. D.

Corol. 2. It is evident that  $v$  is some power of  $s$ , let the Exponent of that Power be  $n$ , *scil.*

$v = s^n$ , but  $\frac{s v}{s-1} = \frac{1}{1-s}$ , therefore  $\frac{s \times s^n}{s-1} =$

$\frac{1}{1-s}$ , *id est*,  $\frac{s^{n+1} + 1}{s-1} = \frac{1}{1-s}$ , therefore  $s^{n+1} =$

$\frac{1}{s-1} \times \frac{1}{1-s}$ , which reduced to a Logarithmick

Equation gives  $n + 1 \times l:s = l:s - 1 + l:\frac{1}{1-s}$ ;

which gives  $n = \frac{l:s - 1 + l:\frac{1}{1-s} - 1}{l:s}$ . Q. E. I. An.

An ANSWER to Mr. Varignon's Reflections upon Spaces greater than infinite.

LET  $BC, AC$  making a right Angle at  $C$  be the Asymptotes of any Hyperbola  $BGA$ ; the Abscisse  $CL = x$ , and Ordinate  $LG = y$ ; and the general Equation to all Hyperbola's

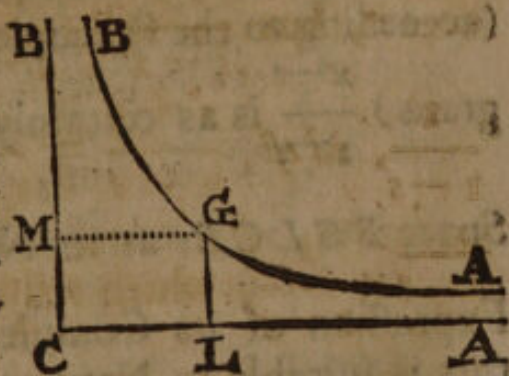
$yx^e = 1$ . Then because  $y = \frac{1}{x^e} = x^{-e}$ , we

have  $y dx = x^{-e} dx$ , therefore  $\int : y dx = \int : x^{-e} dx$ ; but by the Calculus Integralis  $\int : x^{-e}$

$dx = \frac{x^{1-e}}{1-e}$ , therefore  $\int : y dx = \frac{x^{1-e}}{1-e}$ ; But  $\int :$

$y dx = BGLCB$ , therefore  $\frac{x^{1-e}}{1-e} = BGLCB$ ;

This Conclusion (though deduced naturally from Principles which Mr. Varignon acknowledges to be true) he denies, assuring us that it is only the Negative Expression of the Area  $AGLA$



or Complement of  $BGLCB$ , when  $e < 1$  But (without any regard to the Ratio of  $e$  to 1, &c.

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us consider the Algebraical Expressions of these two Spaces  $BGLCB$  and  $AGLA$ ;

we have already found  $BGLCB = \frac{x^{-e}}{1-e}$ ; and

calling the Abscisse  $CM = y$ , and Ordinate  $MG = x$ , we shall from the Equation  $y x^e = 1$ ,

find  $ACMGA = \frac{e \times y |^{\frac{e-1}{e}}}{e-1}$  but  $y^{\frac{e-1}{e}} = x^{1-e}$ ;

therefore  $ACMGA = \frac{e \times x^{1-e}}{e-1}$ , from which if

you subtract  $CMGL = yx = x^{1-e}$ , the Remainder will be (as Mr. *Varignon* says)  $AGLA$

$= \frac{x^{1-e}}{e-1}$ , which is indeed the Negative of  $\frac{x^{1-e}}{1-e}$ .

But his Conclusion is false and groundless, *viz.*

that  $\frac{x^{1-e}}{1-e}$  is not the Expression of the Space

$BGLCB$ , but only (when  $e < 1$ ) the negative Expression of its Complement  $AGLA$ . For (according to the Principles of the Calculus Inte-

gralis)  $\frac{x^{1-e}}{1-e}$  is as certainly the Expression of the

Space  $BGLCB$ , as its Negative  $\frac{x^{-e}}{e-1}$  is the

Expression of its Complement  $AGLA$ . And this is suitable to Nature's Proceedings, *viz.* to do things in the simplest and most general Method, and consequently to give one Expression of

of the Area of a Figure and of its Complement, when it can be done. And may it not (with as good reason) be said that  $\frac{x^{1-e}}{e-1}$  is not the Expre-

ssion of the Space  $AGLA$  but of its Complement  $BGLCB$ ; And not only it may be said, but Mr. *Varignon* must say so in all the innumerable Cafes where  $e > 1$ ; and to say it is not when  $e < 1$ , and it is when  $e > 1$ ; what is this but to say backward and forward, according as it will answer his Conceit of denying that there are Spaces greater than infinite? But to put this Controversy beyond all dispute, let us resolve these two finite Expressions of the Spaces  $BGLCB$ , and  $AGLA$ , into infinite Series's.

$$\text{I. } \frac{x^{1-e}}{1-e} = x^{1-e} \times 1 + e + e^2 + e^3 + e^4, \text{ \&c. when}$$

you begin the Division with 1, as here it naturally should.

$$\text{II. } \frac{x^{1-e}}{1-e} = x^{1-e} \times \frac{1}{e} - \frac{1}{e^2} + \frac{1}{e^3} - \frac{1}{e^4}, \text{ \&c.}$$

When you begin the Division with  $-e$ .

$$\text{III. } \frac{x^{1-e}}{e-1} = x^{1-e} \times \frac{1}{e} + \frac{1}{e^2} + \frac{1}{e^3} + \frac{1}{e^4}, \text{ \&c.}$$

When you begin the Division with  $e$ , as here it naturally should.

$$\text{IV. } \frac{x^{1-e}}{e-1} = x^{1-e} \times -1 + e - e^2 + e^3 - e^4, \text{ \&c.}$$

When you begin the Division with  $-1$ .

Thus

Thus it appears that each of these two Expressions give two Series, of which the first is the Area directly sought, and the other the negative Expression of its Complement; so

$$BGLCB = \frac{x^{1-e}}{1-e} = x^{1-e} \times 1 + e + e^2 + e^3 + e^4 + \&c.$$

$$-AGLA = \frac{x^{1-e}}{1-e} = x^{1-e} \times \frac{1}{e} - \frac{1}{e^2} - \frac{1}{e^3} - \frac{1}{e^4} - \&c.$$

$$AGLA = \frac{x^{1-e}}{e-1} = x^{1-e} \times \frac{1}{e} + \frac{1}{e^2} + \frac{1}{e^3} + \frac{1}{e^4} + \&c.$$

$$-BCLCB = \frac{x^{1-e}}{e-1} = x^{1-e} \times -1 - e - e^2 - e^3 - e^4 - \&c.$$

These are plain and obvious Conclusions deduced from the known and common Operations of Arithmetick, and utterly overthrow all that Mr. *Varignon* alledges against Spaces greater than infinite.

For without any Limitation (except  $e < 1$ ) he says that  $\frac{x^{1-e}}{1-e}$  is not the Expression of  $BGLCB$ , but the Negative of the Space  $AGLA$ . And if so, then (by Series I.) it will follow

follow that  $x^{1-e} \times 1 + e + e^2 + e^3 + e^4, \&c.$  is the Negative Expression of the Space  $AGLA$ ; and this I say implies two manifest Absurdities; (1st) That a Sum of affirmative Quantities is Negative, and (2dly) That the Sum of an infinite Geometrical Progression, whose Terms are continually increasing, is equal to a finite Quantity, *i. e.* That Affirmative is Negative, and Infinite is Finite.

That which seems to shock Mr. *Varignon* is that there should be Spaces greater than infinite, for he tells us expressly that he looks upon this as a Contradiction. But this difficulty will soon vanish, if he considers what is the simple Idea of Infinite; and because he confesses that in the *Apollonian* Hyperbola  $BGA$ , the Space  $BGLCB$  is infinite, therefore let us take the Arithmetick value of  $BGLCB$  for infinite, but in that Hyperbola  $e = 1$ , and therefore (if we put likewise  $x = 1$ ) we shall by Series 1 have  $BGLCB = 1 + 1 + 1 + 1 + 1 \&c.$  that is  $BGLCB = \infty \times 1$  or an infinite number of Units. So that when we say  $2 + 2 + 2 + 2 \&c.$  or  $\infty \times 2$  is more than infinite, no more is meant, but that it is greater then simple infinite or  $\infty \times 1$ ; *i. e.* (taking  $\infty \times 1$  for the Unit, by which we measure Quantities that are infinite)  $\infty \times 2 \angle \infty \times 1$ , or  $2 \angle 1$ .

This will be yet plainer in the Case of finites. It is certain no Quantity can be less than finite  
(as

(as none can be greater than infinite) which we shall denote by  $\odot \times 1$  or  $1$ ; when I say then that  $\odot \times \frac{1}{2}$  is less than  $\odot \times 1$ , I mean no more but that  $\frac{1}{2} < 1$ ; and because I have defined the Idea of finite by  $\odot \times 1$  or  $1$ , I may very properly say that  $\odot \times \frac{1}{2}$  or  $\frac{1}{2}$  is less than a finite Quantity.

September 23. 1713.



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